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Research

Integrated and innovative scenario approaches for sustainable development planning in The Bahamas

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ABSTRACT. Using alternative future scenarios in development planning supports the integration of diverse perspectives and the joint consideration of the needs of humans and nature. Here, we report on the use of scenarios as an integral part of a two-year sustainable development planning process for Andros Island, The Bahamas. We combined qualitative and quantitative approaches to link stakeholder visions of the future of their island with quantitative assessments of the likely impacts of those visions on future conditions. We highlight knowledge gains for scenarios in three key areas: (1) inclusion of participatory mapping as both a mechanism for eliciting stakeholder knowledge and aspirations, and as an input for risk assessment; (2) participation of a transdisciplinary team to guide the scenario creation process and enable better understanding of the range of stakeholder visions and values; and (3) use of cumulative risk assessment as a framework to bring together quantitative and qualitative information and provide objective comparisons between alternatives. We convened over 560 people in 35 meetings and worked with 13 government ministries to create and compare four alternative scenarios consisting of storylines and maps of habitat risk of degradation. We found that one scenario, featuring intensive development, would pose the greatest risk to habitats and worked together to understand which activities could lead to such a future and what interventions could be taken to help avoid it. Ultimately, our collaborative process yielded objective comparisons between alternative future scenarios, incorporated diverse visions and values of stakeholders into the island-wide master plan, and informed investments in the sustainable management of coastal ecosystems and infrastructure critical for the livelihoods of island communities. This process can serve as an example for scientists and practitioners worldwide seeking to use scenarios to inform sustainable development planning.

Key Words: *participatory mapping; risk assessment; scenarios; social-ecological systems; sustainable development planning*

INTRODUCTION

People depend on local ecosystems to provide a diverse array of benefits, from food security to protection from storms. For example, more than 1.3 billion people globally receive at least one-fifth of their animal protein from fish, which depend on coastal vegetation and reefs during various life stages (FAO 2016). Annual expected global damages from storms would double without coral reefs to provide coastal protection (Beck et al. 2018). Reefs also provide $3.6 billion in tourism benefits globally, a sector that generates 10% of global GDP (Spalding et al. 2017, UNWTO 2018). However, the often uncoordinated use of resources threatens these ecosystems and the well-being of people who rely on them (UNESCO 1968, IPBES 2019a).

Cumulative impact and risk assessments—at global (Halpern et al. 2008, 2015, IPBES 2019a, b) and regional scales—(Halpern et al. 2009, Samhouri and Levin 2012, Wyatt et al. 2017) have described mounting threats to ecosystems from human activities such as energy and resource extraction, fisheries, tourism, transportation, coastal development, as well as climate change. These threats to ecosystems, and the potential loss of benefits they provide, are intensified in coastal areas where development pressure and the impacts of climate change are disproportionately high (NOAA 2013, Neumann et al. 2015, IPCC 2019). To navigate pressures from human activities, communities and decision makers need information not just about current conditions, but also about how alternative courses of action are likely to affect their resources and well-being into the future.

Sustainable development planning that integrates biophysical, ecological, economic, political, and other human dimensions can help to support the needs and values of communities, now and into the future (Reed 2008). An integrated approach to planning offers an opportunity to recognize interdependencies between humans and nature (Redman et al. 2004, Folke et al. 2010, Kohler et al. 2017) and address them concurrently by drawing on social-ecological systems perspectives (Berkes and Folke 1998, Colding and Barthel 2019) and transdisciplinary research (Berkes and Folke 1998, Lang et al. 2012, Arkema and Ruckelshaus 2017). Given the complexity and magnitude of overlapping uses in coastal areas, integrated planning and management is especially important in these environments. Fortunately, the approach is gaining traction globally (McLeod and Leslie 2012), and in the Caribbean and Mesoamerican Reef region in particular, where the economic and social well-being of coastal communities are closely tied to the health of ecosystems (Arkema and Ruckelshaus 2017). For example, in 2016, Belize adopted a community-driven coastal zone management plan that addresses the current and future needs of multiple sectors (Arkema et al. 2015, Verutes et al. 2017). In Belize, a team with diverse experience, expertise, and perspectives incorporated qualitative and quantitative knowledge to overcome challenges arising at multiple stages of planning

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(Koontz and Johnson 2004, Verutes et al. 2017). UNESCO's World Heritage Committee had such confidence in the government-approved plan that they de-listed the Belizean coral reef system from their "World Heritage in Danger" status (UNESCO 2018). Not long after, the governments of multiple countries—Mexico, Guatemala, Honduras, and The Bahamas among others—pointed to the success in Belize as evidence for initiating integrated coastal planning efforts in their countries. Replicating the transdisciplinary approach that was taken in Belize could improve outcomes from sustainable development planning across the Caribbean and beyond.

Despite the efforts of scientists and practitioners to work across traditional boundaries, integrated planning processes have been hindered by the difficulty of obtaining and using social information from diverse communities such as human coastal use patterns, activities, ideas, and aspirations (Koehn et al. 2013). One way to include community perspectives and link human well-being and the environment (Kittinger et al. 2014) is through the use of participatory tools (Lynam et al. 2007). Participatory mapping, for example, can help represent local knowledge, values, and needs (Chambers 1994, Lynam et al. 2007, Pomeroy and Douvere 2008). This includes mapping existing and potential benefits from nature, i.e., key fishing grounds, cultural sites, etc. Growing awareness that co-development of knowledge among scientists and stakeholders is indispensable to successful integrated planning processes (Pomeroy and Douvere 2008, Clark et al. 2016a, b, Christie et al. 2017, Torres and Hanley 2017) presents an opportunity to amplify approaches that give communities agency in their futures and improve development planning (Hickey and Mohan 2005, Rudolph et al. 2020).

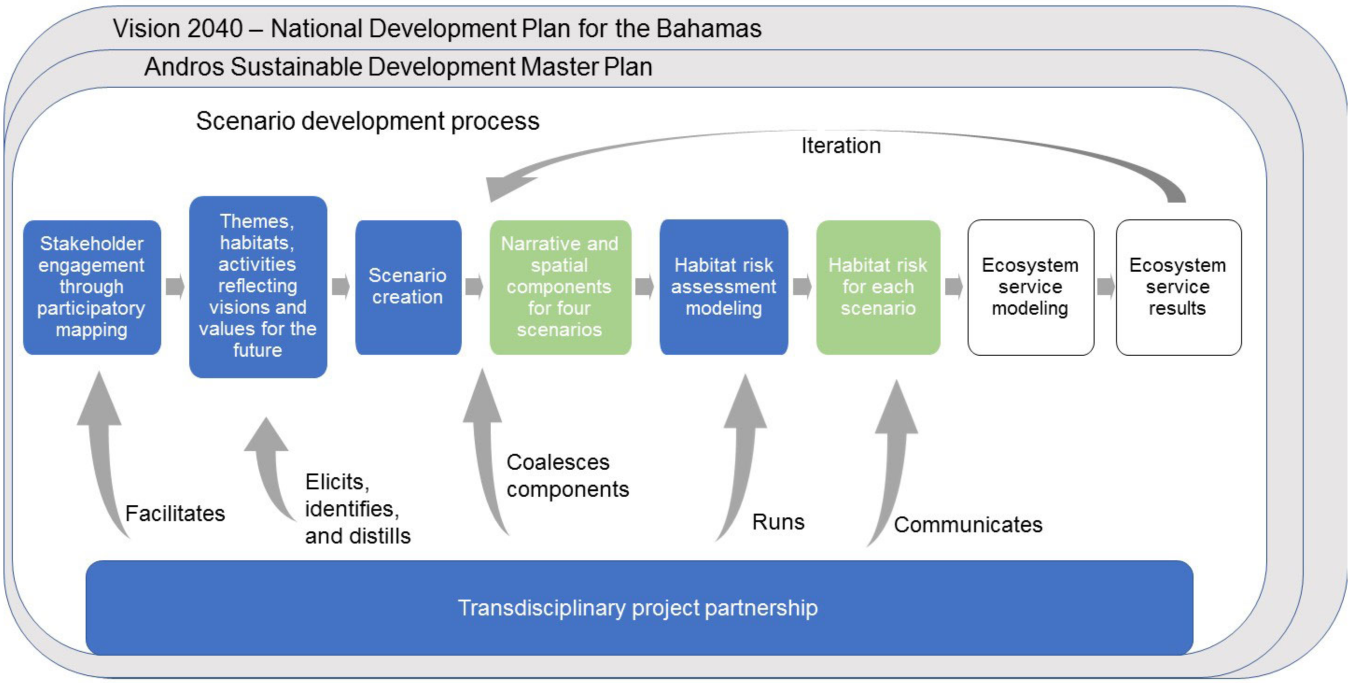
Scenarios are a powerful tool for scientists and stakeholders to explore the dynamics of complex social-ecological systems (Priess and Hauck 2014, Wardropper et al. 2016). Scenarios are "plausible description[s] of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces ... and relationships" (IPCC DDC Glossary: scenario, https://www.ipcc-data.org/guidelines/pages/glossary/glossary_s.html). For example, scenarios could envision a future organized around local agriculture or driven by technological advancement (Carpenter et al. 2015). They can be used to organize complex and critical uncertainties into a limited set of contrasting futures, to anticipate trajectories of possible change, and to evaluate trade-offs (Peterson et al. 2003). The creation process can facilitate the incorporation of stakeholder perspectives for greater credibility, legitimacy, relevance (Akçakaya et al. 2016, Johnson and Karlberg 2017), foster the exchange of information and ideas between community members, and lead to collective action (Johnson et al. 2012, Cobb and Thompson 2012).

Scenarios for integrated planning typically consist of qualitative and quantitative components (Swart et al. 2004, Kok et al. 2015, Booth et al. 2016, Houet et al. 2016, IPBES 2016). Qualitative scenario components weave together the complex dimensions of people's desires for the future into narratives or storylines, (Burnam-Fink 2015, Carpenter et al. 2015, Wardropper et al. 2016, Nilsson et al. 2017, Riahi et al. 2017). Importantly, narratives can be co-produced, i.e., jointly developed by multiple groups, to include diverse perspectives and knowledge systems (Dietz et al. 2003, Folke et al. 2004, Carpenter et al. 2006), which fosters stakeholder engagement, discussion, and trust (Booth et al. 2016, Butler et al. 2016, Tengö et al. 2017). The challenge with qualitative scenarios is that they can be difficult to objectively compare and may lack the numerical information or metrics that appeal to decision makers. Quantitative scenario components provide numerical or spatial descriptions of possible futures and are usually based on computer models, such as climate or economic models (Guivarch et al. 2016, IPCC 2018). This numerical information is often essential to decision making because it allows for objective comparisons between alternative pathways or can be readily linked to policy targets and indicators. For non-experts, however, quantitative scenarios can be too abstract to relate to their own day-to-day needs or longer term desires and they may leave out key factors that are difficult to quantify.

A primary challenge of using scenarios for place-based sustainable development planning is to link co-produced qualitative visions with quantitative assessments into scenarios that resonate with both stakeholders and decision makers (Swart et al. 2004, Houet et al. 2016). Parameterizing complex models may depend on quantitative information such as rates and patterns of land use conversation, which may be difficult to distill from narratives. This may force modelers into an opaque process of interpretation that can limit the ability of stakeholders to drive the process (Kok 2009, Kok et al. 2015, Booth et al. 2016, Houet et al. 2016, Harmáčková and Vačkář 2018). Models, which by their nature simplify reality, may also be limited in their ability to include nuanced environmental, political, and social complexity (Fulton et al. 2011, Müller-Hansen et al. 2017). In some cases, narrative storylines are linked to quantitative models through identification of driving forces and land-use land-cover change models, for example, assumptions around land conversion rates (Alcamo et al. 2005, Nelson et al. 2009, Carpenter et al. 2015, Mallampalli et al. 2016, Kok et al. 2017). However, best practices have not yet been solidified, especially for cases not using land-use land-cover modeling, leaving researchers and practitioners with little guidance. Efforts to integrate qualitative and quantitative approaches are at the forefront of current research needs (Wiebe et al. 2018, Elsawah et al. 2020).

Here, we advance approaches for scenario design and application to inform sustainable development in The Bahamas. As a nation of over 700 islands and cayes, the economy of The Bahamas and well-being of Bahamians are highly intertwined with the health of the coastal zone. Over the past several years, the Bahamian government has been engaged in several integrated management efforts across the archipelago. These efforts make it a ripe place for testing and applying new approaches for scenario design and stakeholder engagement to inform development planning that considers social, ecological, and economic goals. In this paper, we present and highlight knowledge gained throughout a multi-year engagement in The Bahamas. We emphasize three areas in which our team made important advancements: (1) the inclusion of participatory mapping as a tool to elicit and exchange stakeholder knowledge, ideas, and aspirations and as an input for risk assessment modeling; (2) the use of transdisciplinary collaboration to guide the scenario creation process and enable better understanding of the range of stakeholder visions and values; and (3) the application of cumulative ecosystem risk assessment as a framework to bring together quantitative and

Fig. 1. Conceptual diagram for scenario development process. Blue boxes represent steps in the process. Green boxes represent outcomes from those steps. White boxes were critical to the overall project but are not reported upon in this paper. The scenario development process was nested within the Andros Sustainable Development Master Plan and Vision 2040, the National Development Plan for the Bahamas.



qualitative information. The results from our study can serve as a powerful example for scientists and practitioners seeking to use the generation and assessment of scenarios to inform sustainable development planning in communities and nations around the world.

METHODS

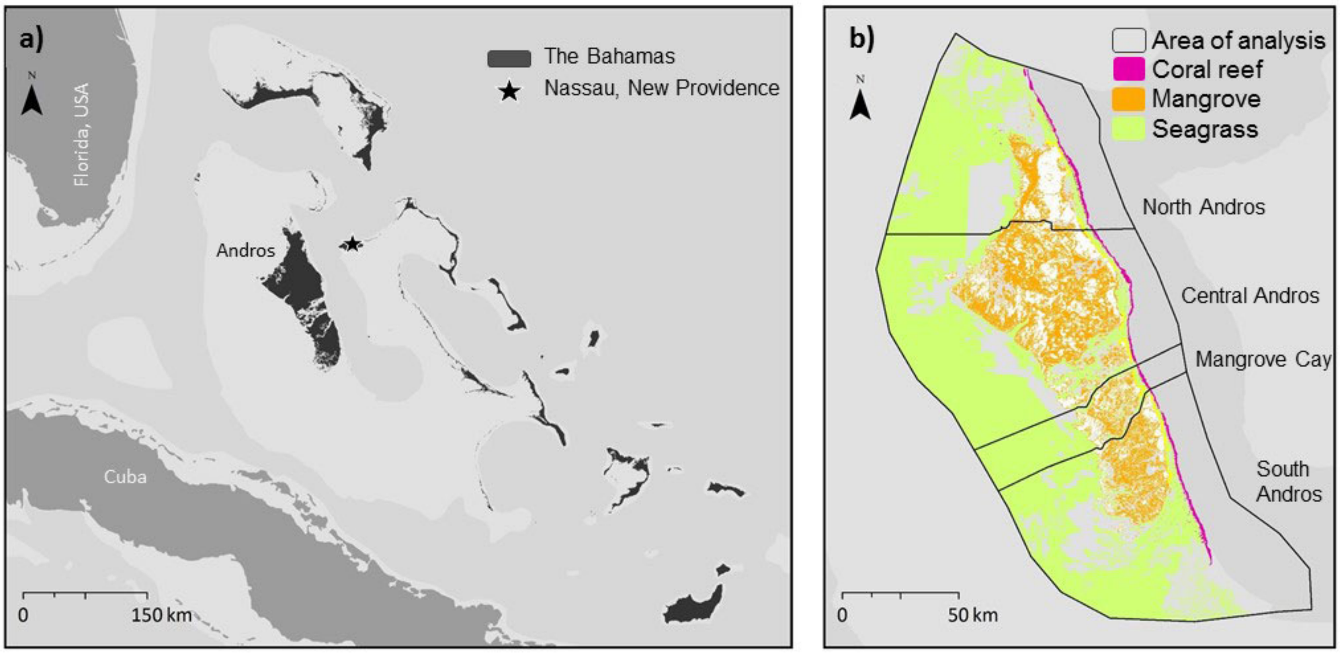
We used a combination of qualitative and quantitative approaches to develop scenarios in support of sustainable development planning in The Bahamas. In the overall science-policy engagement process, we used scenarios as inputs to a series of models linking risk of habitat degradation to the delivery of ecosystem services, to illuminate trade-offs between scenarios (Fig. 1, white boxes). The ecosystem service modeling work is based on an ecological production function approach using the open-source InVEST suite of models (Sharp et al. 2018) and is documented in detail elsewhere (Arkema et al. 2019, 2021, Silver et al. 2019, Ruckelshaus et al. 2020). Here we focus on unpacking the complex and enriching process of developing stakeholder-driven storylines and the steps for translating them into ecosystem service model inputs.

Planning context and team

The Bahamas is located in the northwestern Caribbean, southeast of Florida and north of Cuba (Fig. 2). Its coastal and marine environment not only characterizes the landscape but is central to the country's economy and identity. With a population around 350,000, tourism accounts for 60% of GDP and financial services another 20% (The Commonwealth of The Bahamas 2010, Bahamas Ministry of Tourism 2019). Our study focused on the island of Andros, which is 65 km to the west of the capital, Nassau, on New Providence Island. Andros is the largest island in the country, but it is sparsely populated (7500 residents) and relatively undeveloped (The Commonwealth of The Bahamas 2010). The natural assets of Andros provide innumerable benefits to both the local and larger Bahamian community: sandflats, blue holes, and the third largest barrier reef in the world offer fishing, swimming, and scuba-diving for tourists, while reefs, mangroves, and seagrass beds provide both habitat for commercial and subsistence fisheries as well as protection from coastal storms (Fig. 2; Hargreaves-Allen 2010, Arkema et al. 2019, 2021, Silver et al. 2019).

Despite the wealth of natural resources, Androsians face a host of significant challenges. Terrain bisected by channels and creeks (Holding and Allen 2015), in combination with limited capital, make transportation infrastructure and access to central markets difficult. Ad hoc and informal development risks the health of unique and sensitive ecosystems, such as blue holes, coral reefs, sand flats, and mangroves, which in turn threatens the tourism and economically important species they support (Sealey 2004). Andros, and The Bahamas as a whole, face increasing threats from tropical storms and hurricanes, with 18 major disasters including hurricanes occurring from 1970 to 2021 and nearly half of them occurring in the last 10 years (CRED 2021). A low-lying nation, The Bahamas is highly vulnerable to sea-level rise; one meter of sea level rise would place 36% of major tourism properties, 38% of airports, 14% of road networks, and 90% of seaports at risk

Fig. 2. Andros is the largest island in The Bahamas (a) and comprises four districts: North Andros, Central Andros, Mangrove Cay, and South Andros (b). Mangroves cover much of the island, a barrier reef shadows its eastern shoreline, and seagrass extends off the north and western shores (b).



(Simpson et al. 2010). On Andros, a highly invasive species, *Casuarina equisetifolia*, appears to exacerbate coastal hazards and ecological degradation by increasing both shoreline erosion and loss of native plant species (Hammerton 2001, Sealey 2006, Buehler and Rodgers 2012).

To address these challenges and guide future development, the government initiated a planning process to create the Sustainable Development Master Plan for Andros Island ("Master Plan"; OPM 2017). The objective of the Master Plan was to coordinate and increase economic opportunities while maintaining the nature-based benefits that underpin communities' livelihoods and well-being. This intended island-wide roadmap for the future was part of The Bahamas national development planning process entitled "Vision 2040" (Fig. 1). The Office of the Prime Minister sought to use the Vision 2040 process to implement the international Sustainable Development Goals (SDGs) through the pillars of governance, human capital, the environment, and the economy (Government of The Bahamas 2016). The Master Plan focused on the island's four districts—North Andros, Central Andros, Mangrove Cay, and South Andros (Fig. 2). Each district is managed by a separate local government council and their economies rely on a different composition of tourism, agriculture, and industry.

With support from the Biodiversity and Ecosystem Services Program at the Inter-American Development Bank, our transdisciplinary team was led by the Office of the Prime Minister and included The Natural Capital Project (an international partnership between research and NGO institutions), a conservation organization (The Nature Conservancy), local academics (University of The Bahamas), and a local community engagement group (SEV Consulting Group). The project team brought together credibility, capacity, and experience working at local, national, and regional, i.e., Latin American and Caribbean, scales. Our team represented diverse disciplines including public policy and management, economics, ecology, environmental planning, fisheries, forestry, geography, and social science. Weekly remote team meetings were held for the duration of the project (2.5 years) to ensure integration of all aspects of the work.

Stakeholder engagement through participatory mapping

Stakeholder engagement and participatory mapping

We used broad stakeholder engagement to inform, improve, and explore alternative scenarios as part of informing the Andros Master Plan. We used an inclusive, iterative, and process-based approach that sought to recognize and value place-based livelihoods and well-being while also acknowledging local norms (Christie et al. 2017, Marshall et al. 2017). To understand the range of ideas for the future, we spoke with an array of stakeholders including community members, students, government officials, and local leaders in the fishing, hospitality, and agriculture sectors. We engaged stakeholders in each of the four districts of Andros during six different periods within the project duration (July and September of 2015; January, May, August, and November of 2016). These six rounds of engagement included nearly 35 gatherings in the form of open sessions, town meetings, and additional one-on-one visits (Fig. 3). Over 570 individuals attended these meetings. Many of these conversations utilized the participatory mapping described below, while others were unstructured. In parallel, we met with 13 government agencies (many on multiple occasions) to understand ongoing and planned efforts within various sectors and ministries; for example, the

Fig. 3. The project partners met with stakeholders in the field (a) and in meeting halls (b, c) across Andros throughout the two-year planning process. In the initial phases these conversations focused on understanding the socio-cultural landscape and broad ideas about the future, i.e., visions and values. In addition, stakeholders brought up the most important habitats and human activities on the island. Later conversations included feedback on mapped human activities and habitat risk (d).

Department of Forestry was planning new land designations. Throughout this engagement process, we built and continually improved our understanding of Androsians' visions for the future of their island, communities, and livelihoods and the values underlying these visions. We reflected the information we heard in intermediate outcomes of the planning process (including themes, habitats, and environmental stressors; January 2016), sought details on local issues from flooding to marina expansion (May 2016), gathered further field data and stakeholder input on coastal vulnerability issues, and eventually in alternative scenarios (November 2016). We used these intermediate outcomes and scenarios to check our understanding, elicit feedback from stakeholders, improve the alternative scenarios under consideration for the management plan, and to crystalize stakeholder preferences between scenarios.

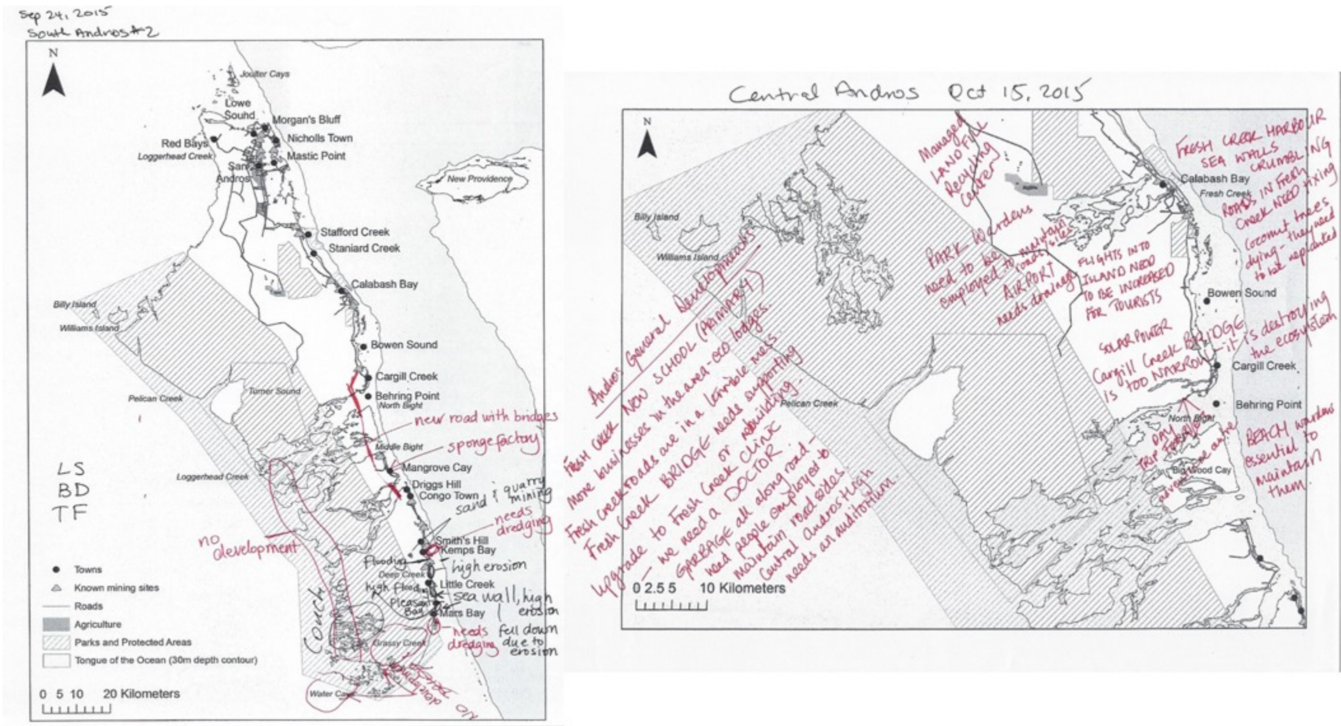
Initial meetings (July 2015) were held in public spaces, e.g., schools, libraries, or government offices. The meeting structure was flexible and ranged from smaller break-out groups within larger gatherings, to semi-structured interviews with individuals representing key sectors. At the outset, the Office of the Prime Minister and the local SEV Consulting Group introduced Vision 2040 as an initiative to create "road maps" for the country and Andros and encouraged Androsians to ask questions and express their concerns and ideas for the future. The focus of these conversations was to understand fundamental issues facing the community, what members wanted for the future of their island and country, important land and sea sectors, and, finally, elements of the natural environment that Androsians rely on for their livelihoods and well-being. SEV led these meetings, and as a local, well-connected consultant, they were a highly effective intermediary (Cvitanovic et al. 2015) between community members and the project team.

We used participatory mapping to better understand communities' current and desired future conditions, providing specificity to the broader themes (e.g., issues of coastal erosion) and environmental stressors (e.g., development or invasive species) expressed during initial stakeholder engagement. During seven open meetings across all four districts (September 2015), we guided individuals and small groups through a mapping exercise. We asked participants to draw and describe current characteristics of the land- and seascape in black and desired future components of the land- and seascape in red (Fig. 4). Specifically, we asked for locations where key activities occurred, e.g., types of fishing, tourism, development, conservation. We also asked participants to identify the locations of activities they would want to see in the future, e.g., additional transportation or fishing, and places that should be restored, developed, or left alone. In cases where participants were not familiar with maps, we worked with them to identify common landmarks and to annotate locations. We encouraged participants to respond to activities or subjects they felt strongly about and add information they felt was important. Participants annotated their maps and the project team took extensive notes. We ultimately collected 108 participatory maps representing over 250 people (Fig. 4).

Intermediate stakeholder outcomes: themes, habitats, environmental stressors

The transdisciplinary team used the participatory maps and associated conversations, including those with government ministries, to identify common themes, key habitats, and important activities, and environmental stressors to incorporate

Fig. 4. Examples of participatory mapping. Black annotations indicate the location of current activities or environmental stressors: for example, areas of erosion and flooding (left) and bonefish lodges. Red annotations indicate the location of desired future activities: for example, bridges across the central bights (left) and areas not to disturb (both). The mapping exercise also elicited ideas for the future that were not spatial: for example, the need for doctors, schools, and park wardens (right).



into scenarios. These elements were directly included in the habitat risk assessment and were used to guide the Andros Master Plan. We shared these themes, habitats, and environmental stressors with the Andros Master Plan Technical Advisory Committee and with community members in subsequent follow-up meetings (January 2016).

The transdisciplinary team coalesced outputs from the many engagements with stakeholders, identified broad values and hopes for the future, and wove them into key themes that reflected what Androsians wanted the Master Plan to address. For example, Androsians discussed concerns around eroding beaches and intermittent hurricanes and these issues were generalized into a "climate and coastal resilience" theme. We also heard the desire for educational and professional opportunities, for additional services, and for changes in land-use policies and governance. There were eight final themes: climate and coastal resilience, education and capacity building, food and water security, health and well-being, land-use planning and enforcement, livelihoods and income equality, transportation for people and goods, and strengthened local government. These eight themes ultimately became the "Key Pillars" of the Andros Master Plan and, through evaluating whether these themes were addressed, a way to gauge its success.

Identifying key themes also informed the selection of ecosystem services we later modeled to compare among development scenarios. For example, to evaluate the differences in "climate and coastal resilience" among scenarios, we modeled coastal risk reduction provided by varying extents of coastal reefs, mangroves, and seagrass. We assessed productivity of agricultural lands and risk to freshwater resources as part of the food and water security theme. We addressed the livelihoods and income equality theme by analyzing habitat quality and extent for lobster production and nature-based recreation, two vital national industries. Habitat risk assessment was a key component to linking changes in scenarios to changes in the delivery of these services (e.g., for example, in the scenario focused on rapid development, additional coastal development and boat traffic degraded coastal habitats and reduced their ability to attenuate waves and storm surge, thereby increasing coastal vulnerability) and providing a mechanism to objectively compare trade-offs between scenarios (OPM 2017).

Stakeholders identified key habitats underlying human well-being and the provision of ecosystem services on Andros both directly, i.e. mentioning that beaches are important for tourism, and indirectly, i.e., by referencing the importance of the lobster fishery that depends on mangrove nursery habitat. From this information the project team selected seven coastal and marine ecosystems to include in the scenarios. These were seagrass, mangroves and wetlands, coral reef, coppice forest, pine forest, and blue holes, bonefish habitat and tidal flats, (Fig. 2, online resource 1). The subsequent habitat risk assessment evaluated the potential risk of degradation to each of these habitats across each scenario.

Table 1. Activity-specific narratives for each scenario. These were developed from community members and ministry input, providing further detail to the overarching scenario narratives. Activity-specific details were checked with local, regional, and global experts to ensure they were plausible. The extent of each activity is represented spatially in scenario maps. Activity-specific narratives informed exposure and consequence scores (e.g. intensity, management effectiveness) in habitat risk assessment modeling.

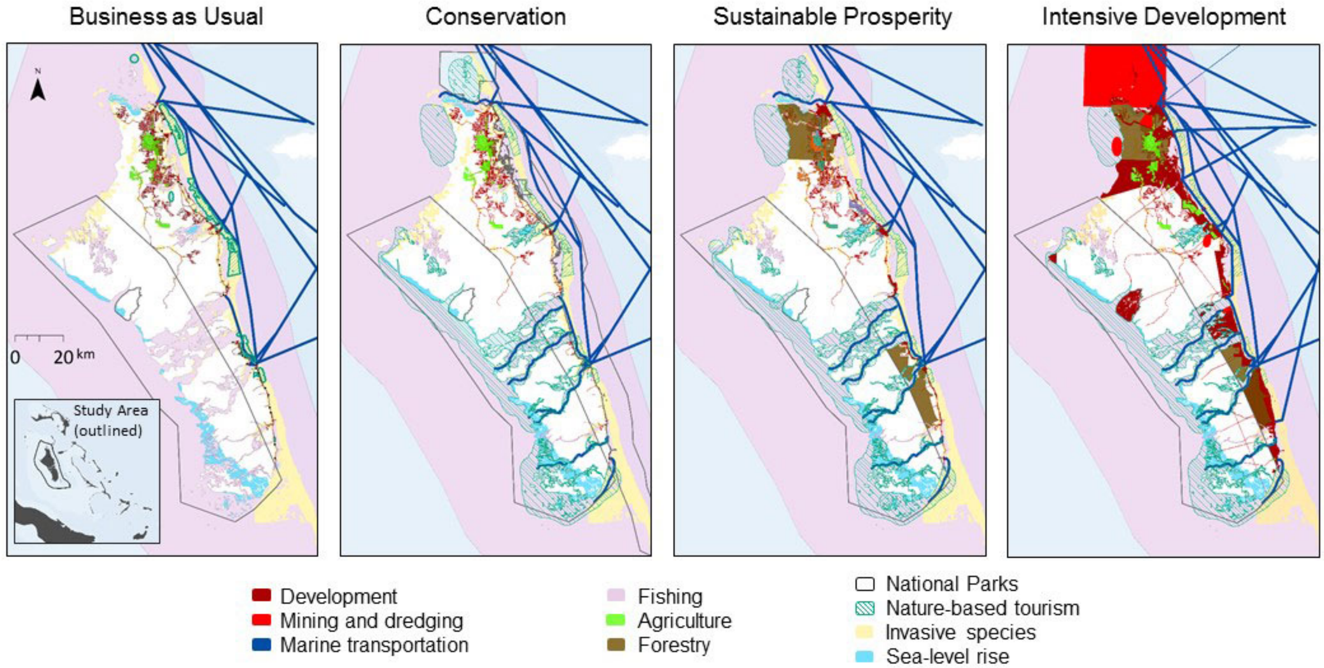
	Alternative Scenarios			
	Business as Usual	Conservation	Sustainable Prosperity	Intensive Development
Develop-ment	No new investment in development	Conservation efforts are prioritized over development. The extent of development does not expand.	Targeted development, for processing factories and public services, are mostly contained within existing settlement footprints.	All land that is open to development, including legally convertible forest land, private land, and "unclassified" land is developed. This includes a new cruise ship port, major roads, and bridge expansion.
Dredging and mining	Mining remains unregulated	Dredging and mining are severely limited, especially within protected areas. Some currently dredged areas are allowed to fill in.	New areas are dredged to support proposed marine traffic. Ad-hoc and local mining remains unregulated. Proposals for large-scale mining are rejected.	New areas are dredged to support larger expansion of marine transportation. Mining remains unregulated and proposals for large-scale aragonite mining proceed.
Nature-based tourism	No new investment in tourist infrastructure or marketing.	No new investment in tourist infrastructure or marketing. Tourist areas and intensity remain relatively unchanged.	Opportunities are expanded for diving, bird watching, hiking, and camping along the west side. Tourism increases but is well-managed.	Developed areas are no longer compatible with tourism activities. There is no new investment in tourist infrastructure or marketing. Tourist intensity remain unchanged.
Forestry	No new forestry activities.	No new forestry activities.	Land that is zoned for timber use by the Dept. of Forestry is used at low intensity	Land that is zoned for timber use by the Dept. of Forestry is used for high-intensity logging.
Fishing	Low-intensity fishing continues around Andros	New, strict fisheries policies and enforcement, including two no-take areas, sustain the fishery through time.	A combination of renewed enforcement and new fishing policies limits the intensity of fishing and improves fishery stocks.	In the absence of regulation and enforcement, fishing pressure by outsiders increases as does the use of destructive fishing practices (e.g., dynamite, bleach).
Transport-ation of goods & people by water	No new investment in ferries, water taxis, or cargo ships. Current routes and intensities continue.	No new investment in ferries, water taxis, or cargo ships. Current routes and intensities continue.	Strategic investment increases intra-island and inter-island (to Nassau) connectivity with new routes and improved reliability. Routes minimize travel over the barrier reef.	Marine transportation greatly increases with additional routes between districts and to Nassau. A new cruise ship port in North Andros is developed.
Agriculture	Current issues with agricultural management persist and there is no coordinated implementation of best practices.	Land zoned for commercial agriculture is farmed using best management practices. Settlements also develop small-scale agriculture.	Land zoned for commercial agriculture is farmed using best management practices. Settlements also develop small-scale agriculture.	Intensive agriculture expands on lands zoned for commercial agriculture and around settlements, but best management practices are not followed, and water contamination continues to be an issue.
Invasive Species *Casuarina* and lionfish	Invasive species remain uncontrolled and expand in location and density.	Although extents remain similar, lionfish density is controlled through harvest and *casuarina* is managed to reduce their impact on native habitats.	Though their extents expand, lionfish density is partially controlled through harvest and coastal management plans are developed for *casuarina*.	Casuarina and lionfish remain uncontrolled and expand in extent and density.
Sea-level rise	2 m rise in sea-level, affecting the west coast and southern tip of Andros	2 m rise in sea-level, affecting the west coast and southern tip of Andros	2 m rise in sea-level, affecting the west coast and southern tip of Andros	2 m rise in sea-level, affecting the west coast and southern tip of Andros
Protected areas	No new parks or protected areas are designated. Enforcement of existing regulations remains limited.	New national parks, including Joulter Cays and Great Barrier Reef National Park, are designated. Management and enforcement of all parks improves.	New national parks, including Joulter Cays and Great Barrier Reef National Park, are designated. Management and enforcement of all parks improves.	Regulation and enforcement of existing parks is limited, and no new parks are designated.

Finally, we identified human activities and environmental stressors that are important for management, and that unmanaged have the potential to degrade key ecosystems. Stakeholders mentioned many of these activities and stressors directly, for example, additional fishing and infrastructure development were commonly part of visions for the future, e.g., develop a town center or protect a specific area for fishing. The transdisciplinary team worked to group activities and stressors into categories that reflected commonalities among them, for example combining terrestrial and aquatic invasive species into a single category. In total we considered 10 human activities and environmental stressors including development, dredging and mining, nature-based tourism, transportation of goods and people by water (i.e. marine transportation), fishing, forestry, agriculture, invasive species, sea-level rise, and protected areas. The spatial and management extent of each of these stressors were defining elements of the scenarios, with narratives and spatial maps for each stressor in each scenario (Table 1, Fig. 5, online resource 1). The spatial extent and consequences of these activities and environmental stressors were also direct inputs into the habitat risk assessment model, allowing us to evaluate the cumulative effect of each scenario on the key habitats.

Scenario creation and improvement

To create spatial and narrative components for multiple scenarios (Fig. 5, Table 1) we first turned elements of the hand drawn maps

Fig. 5. Maps of the final spatial depiction of the four future scenarios. Maps show the distribution of all human activities and stressors included in the scenarios and Habitat Risk Assessment. These were the results of several iterations of the process described in Figure 1 and were accompanied by scenario narratives and non-spatial data and parameters (Table 1).



and the associated conversations into spatial representations (effectively "digitizing" the hand-drawn maps). This included digitizing depictions of current activities and those envisioned for the future. In some cases, this was a direct digitization of a drawing completed by a community member. For example, we created a polygon in a GIS outlining a proposed cruise ship port and expanded town center drawn in North Andros exactly as drawn by a stakeholder. In other cases, we used the annotations and notes to create spatial representations and sought feedback from stakeholders to accurately size and locate elements. For example, stakeholders and several ministries discussed the need for an increase in ferry service and the desire for greater connectivity across the island and with Nassau, the capital. We reflected this proposal with additional routes for fast ferries. Members of the transdisciplinary team worked with local experts to understand relevant local history and to translate ideas into spatially explicit representations. For example, the project team's economist and ecologists worked with national park and fishing enforcement employees to understand how to interpret and represent different stakeholder ideas for managing the fishery.

These participatory maps and the associated notes highlighted differences and commonalities between stakeholders, forming the basis for how ideas were grouped or separated to form discrete scenarios. For example, because some stakeholders strongly disagreed about the future of their island, some spatial elements directly overlapped and contradicted one another, as was the case for dueling proposals to turn Joulter Cays into a National Park versus opening it up to international investors for aragonite mining. In other instances, incorporating multiple ideas may have been physically possible, but represented fundamentally different visions for the future, for example, suggestions for a large-scale development with high-rise apartments contrasted with minor expansions to town centers. The process of creating scenarios also highlighted commonalities. For example, a suggested cruise ship port in North Andros seemed consistent with proposals for a large resort and golf course in South Andros. Elements that supported either extensive development or extensive conservation were relatively straight forward to group and separate, but there were also a range of ideas that fell in between. A narrative around strategic, but limited development started to emerge. For each of these preliminary narratives the transdisciplinary team discussed how each of the 10 activities or environmental stressors might vary. For example, what might forestry look like on an Andros under a scenario that prioritized extensive development, both spatially and conceptually?

We used the spatial and narrative components of the scenarios to reflect back to communities what we had heard and to encourage further dialogue (Fig. 5, Table 1; Peterson et al. 2003, Alcamo and Henrichs 2008, Oteros-Rozas et al. 2015). We elicited feedback from Androsians, from the larger project team, and the Technical Advisory Committee to ensure the emerging alternative scenarios were geographically, politically, and socio-culturally consistent and feasible. We shared activity-specific maps and narratives (Table 1), e.g., of forestry or development, with each respective group and highlighted areas of uncertainty. Stakeholders identified elements they agreed with and those they felt were implausible, for example, remarking that the difficulty of invasive species removal meant that it would realistically be limited to select locations or that ad-hoc mining on roadways and beaches for building materials was unlikely to stop without substantial government action and new supply chains. They also identified inconsistencies and interdependencies between narratives within each pathway, for example, noting that on-island crab processing and high-end tourism would require improved access, i.e., additional ferries, to the capitol. Stakeholder input was especially important for the scenario that combined strong elements of both conservation and development, in order to craft narratives that were not simply the middle ground between two extremes. For example, development in this scenario was relatively small in extent and focused heavily on local businesses and high-end tourism, which, in turn, required new and improved roads. This transparent process not only improved the plausibility of the scenarios, but also served to build trust as individuals saw and heard their ideas reflected in the scenario components.

Habitat risk assessment modeling

We conducted an ecosystem risk assessment for two, inter-related reasons. First, and most importantly, risk assessment provided a transparent mechanism to combine and translate stakeholder identified themes, activities, and habitats into spatially explicit inputs for the ecosystem service models, thereby enriching the narratives and discussion of scenarios. Second, risk assessment provides an objective comparison between alternative pathways, which is often requested by planners and decision makers.

To conduct the assessment, we applied the InVEST habitat risk assessment (HRA) model (Arkema et al. 2014, Wyatt et al. 2017, Sharp et al. 2018). The model is based on a classic risk framework that combines components of exposure and consequence to determine cumulative impacts for different habitats and under different scenarios (Hobday et al. 2011, Samhouri and Levin 2012). The model combines spatial data about the presence of habitats and human activities (or natural stressors) with non-spatial information in the form of criteria scores (ranked from 1 to 3, online resource 1) that define the interaction between habitats and stressors in terms of various components of exposure and consequence. These criteria scores are based on peer-reviewed literature, gray literature, and expert opinion. Exposure is the degree to which a habitat experiences a stressor, and consequence is the effect of that interaction on the habitat (Patrick et al. 2010, Hobday et al. 2011, Samhouri and Levin 2012, Astles 2015). In this study we use criteria from Arkema et al. (2014). Exposure included three components: temporal overlap, management effectiveness, and intensity. Consequence included four habitat specific properties—recruitment rate, natural mortality rate, connectivity, and recovery time—as well as three components specific to the activity: frequency of disturbance, change in area, and change in structure (see Arkema et al. 2014, Sharp et al. 2018, and online resource 1 for further description of each of these factors). The model averages the set of exposure scores and the set of consequence scores for each habitat stressor interaction and then calculates risk as the Euclidean distance to the origin in a consequence-exposure plot (Sharp et al. 2018). Cumulative risk for each habitat is the sum of stressor-specific risk co-occurring in a given location. From this continuous risk range, the model categorizes risk, i.e., into low, medium, and high, based on the maximum number of possible overlapping stressors for each habitat to create categorical risk maps (Sharp et al. 2018). The area of habitat in each risk category is an output of the model and was also confirmed with GIS software.

The transdisciplinary team used the flexibility provided by HRA to include, and represent spatially, the habitats and stressors identified through stakeholder engagement and participatory mapping (Fig. 5,online resource 1). To determine and map the spatial extent of current habitats and stressors, we relied on, and often combined, multiple data sources including aerial imagery from Rapideye (2009, 5m resolution) and Landsat (2005, 30m resolution), prior research efforts, and expert opinion (see online resource 1 for additional information). Local experts vetted many of the global and regional datasets and the transdisciplinary team updated the input data accordingly, a process which increased the quality of the data, despite the remote location (see online resource 1). For example, we combined data from multiple sources to map the current extent of development. We first digitized the footprint of development on aerial imagery, supplemented it with updated road data provided by the government, and added features drawn or mentioned by community members, e.g., small marinas or new infrastructure. For future scenarios, we built on the current development footprint to reflect stakeholder ideas and government plans. Categorizing and representing each activity provided an opportunity to return to community members to share the synthesis of their ideas. Although returning to community members was time consuming and required additional resources, it was extremely important to ensure we had reflected their intent correctly, enriching the scenarios, building trust, and demonstrating that their visions and values were at the core of the planning process. Over the course of several meetings, we presented maps of each environmental stressor and received feedback, which we used to improve the spatial depiction and understanding of activities and stressors.

Stakeholder engagement also informed the risk criteria scores in HRA. In many cases, this link was made through the activity-specific narratives for each scenario, combining community ideas with the local knowledge of our transdisciplinary project team and peer-reviewed literature. Criteria in the HRA model require information on the intensity and effect of stressors on habitats. To determine, for example, the impact of fishing on seagrass and mangroves, our fisheries expert incorporated information about the intensity and effect of fishing practices from local conversations, regional trends, the Department of Marine Affairs, and primary literature.

To understand drivers of risk, we explored the extent of spatial overlap between stressors and habitats and leveraged additional outputs of the HRA model. HRA outputs also include maps of stressor-specific and total risk scores for each habitat, as well as a risk plot of exposure and consequence that allows for comparison of risk between stressors for a given habitat (see Arkema et al. 2014, Wyatt et al. 2017 for additional details on HRA outputs). The transdisciplinary team used these additional outputs to unpack results internally; however, we found that the cumulative risk, habitat, and stressor maps were most accessible for stakeholders and useful in the engagement process. Thus, we include the latter results and outputs as figures in this paper because they were more useful for stakeholders.

Together, the team used the HRA model as an organizing framework to enrich the narrative and spatial scenarios. Each component included in HRA, from habitats to the spatial extent and impact of activities, was rooted in stakeholder ideas, in addition to independent scientific information. We brought the HRA model outputs—maps of habitat risk of degradation under alternative scenarios—back to communities as a way to visually compare scenarios and to elicit feedback.

RESULTS

Narrative and spatial scenarios

The transdisciplinary team developed four alternative scenarios based on ideas and aspirations for the future expressed during the participatory mapping and broader stakeholder engagement (Figs. 3, 4). Each scenario incorporated the themes, habitats, and environmental stressors that were identified during the stakeholder engagement. For each of the four scenarios, along with the current situation, we developed overarching narratives as well as activity-specific storylines and maps (Fig. 5, Table 1).

The four future scenarios were named “Business as Usual,” “Conservation,” “Sustainable Prosperity,” and “Intensive Development.” The Business as Usual scenario reflected status-quo future under which no Master Plan was created. This scenario was characterized by limited international or domestic investment in new infrastructure, educational opportunities, or development. In contrast, the Intensive Development scenario described a future with an emphasis on traditional economic investment and growth with minimal consideration of natural resources. This scenario reflected some stakeholder’s desires for greater development including a cruise ship port, large hotels, and extensive marine transportation. Another storyline emerged that emphasized the desire of some stakeholders to maintain their current nature-based livelihoods and more carefully conserve and restore natural resources. This Conservation narrative included protecting habitat and fishing areas that support commercial, subsistence, and recreational fishing stocks. The final storyline and scenario, Sustainable Prosperity, included both investment in conservation and strategic economic development. This scenario limited large-scale investment and instead focused on smaller-scale development, such as high-end fishing lodges, value-added forestry, and investment in small ferries. This scenario captured some stakeholders’ preferences for specific kinds of development, e.g., locally run and higher-end lodges, and new market opportunities, but also a desire to maintain the natural resources that underpin the local economy, e.g., fishing and tourism, and sense of place (Fig. 5, Table 1).

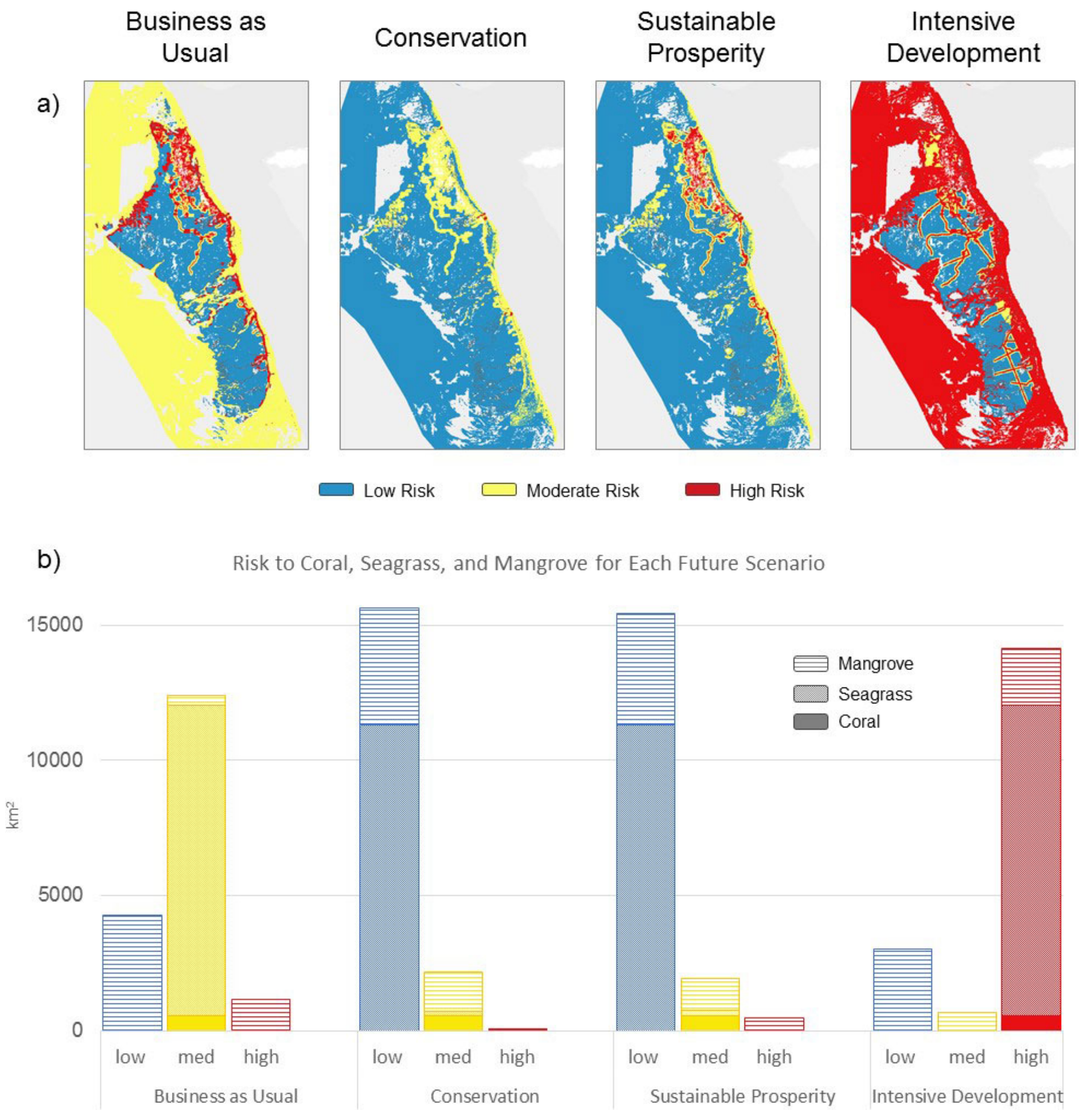
To add specificity to the overarching scenario narratives, we developed a corresponding set of storylines (Table 1) and maps (Fig. 5) for each human activity or environmental stressor. These storylines and maps helped to provide specificity about the intent, intensity, extent, and impact of each human activity. The rich information in Table 1 represents the synthesis of numerous and iterative conversations with stakeholders, local experts, and the interdisciplinary team to ensure general ideas for the future of Andros were consistent with stressor-specific narratives. In some cases, stressor-specific narratives were suggested by stakeholders; in other cases, they were extrapolated from the broader narrative. For example, fishing and forestry were highly regulated and focused on sustainable catch and value-added products in the Conservation scenario and more extractive in the Intensive Development scenario (Table 1). Development in the Business as Usual and Conservation scenarios was limited to the existing footprints of current settlements; the Sustainable Prosperity scenario expanded development around select settlements to support local industry; and the Intensive Development scenario greatly expanded development along the entirety of the coast, consistent with interest in large-scale development (Fig. 5). The scenarios incorporated broad values (e.g., to protect the barrier reef for fish and diving), features from participatory mapping (e.g., where to put new infrastructure), existing development proposals (e.g., for development in South Andros), and parallel planning processes (e.g., forest designations).

Habitat risk for each scenario

The habitat risk assessment indicated that the Intensive Development scenario would pose the greatest risk to all habitats and that the Business as Usual, Conservation, and Sustainable Prosperity scenarios would pose similar degrees of risk to all habitats. Here and in the Sustainable Development Master Plan we focus on coral reef, seagrass, and mangroves as illustrative of broader results and because they provide the coastal protection, fisheries habitat, and tourism benefits most frequently mentioned by stakeholders as important (Fig. 6; OPM 2017, Arkema et al. 2019, 2021, Silver et al. 2019). The results of our modeling suggested that all coral reefs are at high risk in the Intensive Development scenario. In contrast, the vast majority of coral reef area would be at medium risk in the Business as Usual, Conservation, and Sustainable Prosperity scenarios. The small remaining areas of high-risk reef area occur offshore of major settlements. In contrast to coral, we found greater differences between scenarios for seagrass. Currently, and under the Business as Usual scenario, nearly all seagrass habitat would be at medium risk, while under the Conservation and Sustainable Prosperity scenarios, nearly all seagrass habitat would be at low risk (Fig. 6). As with coral reefs, all seagrass habitat was at high risk in the Intensive Development Scenario. There were additional differences in the amount of medium and high risk between scenarios for mangroves. In the Business as Usual scenario, 20% of mangrove was at high risk and 6% was at medium risk. In the Conservation scenario, overall risk decreased; less than 1% of mangrove area was at high risk and 25% was at medium risk. The Sustainable Prosperity scenario fell between Business and Usual and Conservation with 20% at medium risk and 7.5% at high risk. Nearly half the mangrove area in the Intensive Development scenario was at medium or high risk (Fig. 6).

Development, shipping, fishing practices, and invasive species were the primary drivers of risk, with variation between scenarios and habitats. For mangroves, differences in the extent of high-risk area between scenarios corresponded to differences in the extent and intensity of coastal development and invasive species, which were greater in the Intensive Development scenario than the other scenarios. For seagrass and coral reef habitats, the areas of greatest risk in the Conservation and Sustainable Prosperity scenarios corresponded to the expansion of dredging and shipping routes. Increased intensity of fishing practices around Andros posed a higher risk to the full extent of seagrass and coral in the Intensive Development scenario. In summary, the cumulative risk (Fig. 6), stressor (Fig. 5), and habitat (Fig. 2) maps helped the transdisciplinary team and stakeholders to together explore these causes of risk and where they occur.

Fig. 6. Habitat risk to mangroves, seagrass, and coral under each future scenario. Figure 2 shows the distribution of each of these habitats: mangroves occur across much of the island, seagrass in the waters around the island, and the coral reef runs parallel to the eastern shoreline. Risk to each habitat is spatially explicit based the location of activities and their relative exposure and consequence for each habitat (a). Total mangrove habitat is 5759 km², seagrass covers 11,491 km², and coral covers 552 km². Summarized across Andros, risk for all habitats is modeled to be greatest under the intensive development scenario (b). Risk is comparable between Conservation and Sustainable Prosperity scenarios, but slightly lower for mangroves under the Conservation scenario.



DISCUSSION

A successful approach

In this paper we report and reflect on our process of integrating qualitative information from stakeholders with quantitative assessment to design scenarios for sustainable development planning. We demonstrate how participatory mapping, as part of stakeholder process, can be used to capture specific visions for the future as well as the motivating values behind them. Our transdisciplinary team allowed us to combine diverse ideas and data sources into four scenarios with narrative and spatial components. We also illustrate how using a flexible habitat risk assessment model can provide a framework to incorporate alternative ideas, generate objective comparisons of the status of habitats under future scenarios, and further focus stakeholder conversations. Initially, some stakeholders were adamant about including elements of the Intensive Development scenario and others were completely against new development. However, across multiple iterations, stakeholders began to understand the impacts of different development pathways, e.g., increased risk to mangrove and associated declines in lobster catch, and made numerous constructive changes to the scenarios to reduce negative and increase positive outcomes. Ultimately, communities on Andros and the project team used the iterative modeling and feedback process to build consensus around the Sustainable Prosperity scenario, which minimized risk to habitats while also promoting strategic development, greatly improving outcomes compared to a Business As Usual pathway. (Details of the modeled ecosystem service outcomes from the scenarios are documented elsewhere [Arkema et al. 2019, Silver et al. 2019, Ruckelshaus et al. 2020.])

With stakeholder support, the Sustainable Prosperity scenario became the backbone of the Sustainable Development Master Plan for Andros Island that was published and presented to Androsians and the government of The Bahamas in 2017 (OPM 2017). The Master Plan was successful in generating a roadmap that prioritizes biodiversity and ecosystem services as key to underpinning Androsians' sustainable development goals. The Master Plan led to subsequent mobilization of $35 million in loans from the Inter-American Development Bank for coastal management (of which $3 million was specifically directed to climate-resilient coastal "green" infrastructure on Andros) and millions in funding for management of Marine Protected Areas across The Bahamas (Ruckelshaus et al. 2015, IDB 2017, Stevenson et al. 2020).

Knowledge gains for scenario planning

We further reflect on three components of the process that we consider key to its success and synthesize insights for the scenario community.

Participatory mapping

As described above, the development of the Andros Master Plan was part of a larger national development planning process for The Bahamas (Vision 2040) that involved several rounds of stakeholder engagement on islands across the archipelago but did not involve participatory mapping. Several of the authors played a role in both processes. We observed that participatory mapping as part of the master planning process captured Androsians' desires for the future of their island, allowed participants to review and revise the knowledge they shared, facilitated an exchange of ideas within the community, and affirmed the power of stakeholders in the process in a way that engagement based on discussions alone did not seem to do. The maps effectively served as a tool for communication both among community members and between the transdisciplinary team and the stakeholders. The maps allowed individuals from different sectors, parts of the island, and perspectives to share ideas and learn from one another (Kenter 2016). For example, a handful of individuals advocated for bridges across the waterways that segment the island (Fig. 4 and Intensive Development scenario in Fig. 5) in order to enhance business connections; commercial lobster fishermen saw the placement of these bridges in the maps and shared how they would adversely affect habitat and the boat-based transportation essential to other industries. This type of open exchange of information (e.g., Fig. 5, Table 1) altered the scenarios, e.g., bridges were not included in scenarios that sought to meet fishing needs, and increased community cohesion around shared values (Irvine et al. 2016, Kenter 2016). Eliciting information from stakeholders through their drawings, notes, and conversation around the maps and, importantly, returning during subsequent visits with synthesized and digitized versions of their maps also validated stakeholder viewpoints by conveying that such local knowledge was central to the planning process (Clark et al. 2016b).

A transdisciplinary journey

The transdisciplinary approach allowed us to combine the wealth of visions and values expressed through stakeholder engagement into alternative representations of community desires and ensure confidence in the process and outcomes (Posner et al. 2016a). Social-ecological systems theory suggests the importance of the transdisciplinary effort to bring together research and governmental perspectives, local and national scales, and expertise from across disciplines (Lang et al. 2012, Verutes et al. 2017). For example, many Androsians desired a thriving lobster fishery to support themselves and future generations; this desire was merged into scenarios along with an understanding of current fishery stocks, fishing policy and management, habitat dependencies, and national industry. The project partners were able to draw on the dual sources of stakeholder and personal expertise to represent alternative community ideas about fishing both qualitatively (i.e., what kinds of fishing, in what intensity, with what kind of management) and spatially (i.e., maps). Bringing together a myriad of expertise and data sources, the transdisciplinary team was able to synthesize and reflect the wealth and complexity of community desires heard across locations and meetings (Clark et al. 2016a, b, Arkema and Ruckelshaus 2017).

Cumulative risk assessment

The flexibility of the InVEST habitat risk assessment model offered a way to transparently include diverse sectors and data sources, merge qualitative and quantitative components, generate maps of habitat status under future scenarios to input into ecosystem service models, and provide objective comparisons between scenarios. In doing so, we realized the promise of scenario analysis outlined by others (Swart et al. 2004, Booth et al. 2016, Houet et al. 2016, Wardropper et al. 2016, Kok et al. 2017) and actualized and elaborated on Wardropper et al.'s (2016) suggestion that a successful scenario framework include stakeholder participation, knowledge integration, and quality control. The elements of HRA inputs and the resulting risk maps provided a tangible way to reflect back to communities what we had heard and to encourage further dialogue (Peterson et al. 2003, Alcamo and Henrichs 2008, Oteros-Rozas et al. 2015). We were able to represent the scenario narratives quantitatively through criteria scores and the selection of key habitats and activities. We integrated multiple sectors in the HRA model by including them as alternative stressors. Moving beyond the constraints of land-use/land-cover based modeling (Booth et al. 2016), we relied on varied data sources for the distribution of habitats and activities, from participatory mapping to existing development proposals to aerial imagery. The risk analysis strengthened the scenarios by identifying areas where reducing risk would be especially important for the provision of benefits.

Cross-cutting: iteration and capacity building

Across the three components of the process that we highlight—participatory mapping, transdisciplinary collaboration, and habitat risk assessment—iteration and capacity building were integral to a successful process and outcome (Rosenthal et al.

2015). At each junction in the process where the project partners interpreted or synthesized community input, we strove to do so transparently and to report back the outcome to stakeholders. For example, after the initial round of engagement, we synthesized ideas into eight themes and then presented these to stakeholders in a subsequent meeting for feedback. We similarly worked through identifying important human activities and stressors, and the creation of spatial and narrative components of scenarios (Fig. 5, Table 1). This deliberative process not only fostered intra-stakeholder learning as described with participatory mapping above, but also learning between stakeholders, scientists, and practitioners (Priess and Hauck 2014, Kenter et al. 2016). The meaningful, transparent, and iterative nature of the engagement built trust over time and enhanced project legitimacy and impact (Posner et al. 2016b).

Lessons for improvement

Despite the successes of our approach, three key limitations warrant further discussion. First, the engagement by the project team may have biased the process and outcomes to varying degrees. Specifically, the transdisciplinary team named the scenarios and these names, e.g., Sustainable Prosperity, may have biased their reception. In spite of this naming, a large proportion of stakeholders initially preferred the Conservation scenario. Outlining both the Conservation and Intensive Development scenarios helped to explore development and conservation areas (Fig. 5) as well as risk to habitats between scenarios; this ultimately fostered improvement of the Sustainable Development scenario by incorporating desired elements of other scenarios. To avoid this real or perceived bias in naming, we suggest having stakeholders determine their names.

A second challenge was relatively low trust in government at the start of engagement and the constrained two-year time frame. Government mistrust stemmed from participants feeling that past government engagements had not produced results and from frustration with the national land tenure system. In addition, the project terms and funding limited the number of possible meetings and, as a result, our ability to communicate all of the information thoroughly, even with multiple stakeholder visits over two years. We attempted to overcome these challenges by listening to and acknowledging the concerns of residents and clearly stating the objectives and limitations of the project in an effort to set realistic expectations. Throughout the entire engagement process, our local (to Andros and The Bahamas) project partners at SEV and University of The Bahamas functioned as effective knowledge brokers between community members and the governmental and scientific arms of our partnership (Cvitanovic et al. 2015). The open-ended structure of our meetings and nearly two years of engagement built trust with communities and enabled honest input from stakeholders. Wherever possible, we suggest leveraging existing planning efforts and ensuring adequate time and funding for thorough stakeholder engagement.

Third, the stakeholder engagement may not have captured all perspectives equally or may have, unwittingly, through our own underlying assumptions, perpetuated particular power dynamics or world views (Nilsson et al. 2017). Explicit conversations about these power dynamics may have helped to reduce them. We sought to incorporate diverse perspectives by using varied engagement approaches (from one-on-one, to open houses, to interactive community meetings) and in building our transdisciplinary project team. From our understanding, belief in the importance of the eight key themes (climate and coastal resilience, education and capacity building, food and water security, health and well-being, land-use planning and enforcement, livelihoods and income equality, transportation for people and goods, and strengthened local government) was shared among most Androsians. Finally, although some themes were evaluated through ecosystem service modeling, e.g., coastal resilience and water security), we were not able to quantitatively assess others, e.g., health and education. Regardless, we hope that identifying and including these themes elevates them for future planning and decision-making purposes.

CONCLUSION

The process we deployed offers a replicable approach for including stakeholders in sustainable development planning in ways that benefit communities and decision makers. The final Sustainable Prosperity scenario selected to form the basis of the Andros Master Plan reflects better outcomes for more stakeholders than do any of the other scenarios (Business as Usual, Intensive Development, or Conservation). The science-based stakeholder engagement process we employed here can effectively harness different ways of knowing about a system and surface a future development pathway that diverse stakeholders can enthusiastically strive to meet. We reflect on the entirety of the process, illustrating how participatory maps can function as a tool for intra-community learning and for eliciting specific ideas for the future and the guiding values behind them. We explore how a transdisciplinary team built trust by effectively incorporating multiple sectors and perspectives. And we demonstrate how cumulative habitat risk assessment can bring together narrative and spatial scenario components. The qualitative narratives reflected local desires, while quantitative comparison between scenarios and the selection of the Sustainable Prosperity scenario offer an objective and defensible roadmap for the future. Just as these components provided guidance to the central government in The Bahamas, this approach offers a framework for the development of scenarios as part of the Sustainable Development Goals or Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/12764

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Data Availability:

The data/code that support the findings of this study are openly available in OSF at https://osf.io/79nmw/

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