CHARACTERISTICS OF CULTURAL ECOSYSTEM SERVICE MANAGEMENT:

LOCAL SCALE MANAGEMENT YIELDS LARGE-SCALE BENEFITS

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DEDICATION

To my devoted support crew: my husband Traben, my mother Marti, and my sisters Kate, Audrey, Janet, and Sarah whose unflagging encouragement provided more reassurance than they know, and to the memory of my dear father Terry.

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ABSTRACT

Cultural ecosystem services (CES) substantially contribute to human wellbeing as nonmaterial benefits of ecosystems. However, they remain poorly understood due to their often nonmarket and intangible nature. Through electronic surveys with coastal resource managers in Hawaii, the management characteristics of coastal and watershed-based CES in contrast to provisional and regulatory services were analyzed. The results indicate that although CES are a high management priority, only 10.0% of respondents could articulate specific policies currently in place. Additionally, most CES were managed for security, and were largely managed by local, county or state non-governmental organizations. Telephone surveys further revealed that half of all CES managed were considered to benefit humans beyond the spatial scale in which management decisions were made. Understanding the management characteristics of CES is expected to provide a framework for the development of CES that can be used to monitor, assess, and develop effective natural resource policies.

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LIST OF ABBREVIATIONS

CES	Cultural Ecosystem Service
ES	Ecosystem Service
InVEST	Integrated Valuation of Environmental Services
MEA	Millennium Ecosystem Assessment
NGO	Nongovernmental Organization
PES	Payments for Ecosystem Services

CHAPTER 1

INTRODUCTION

Many of the world's ecosystems are being degraded due to an increasing human population, resulting degradation of native ecosystems, and a lack of coordinated management (Vitousek et al. 1997, MEA 2005, Crowder et al. 2006). With increasing pressures on ecosystems to provide more services with less capacity, environmental managers are forced to make decisions that involve tradeoffs between the growing human demand for goods and services and long-term protection of ecosystems. The ecosystem services framework has emerged as a promising conceptual tool for navigating such ecological and sociological tradeoffs since it recognizes ecosystem structure and function as they relate to human utility and values (Daily 1997, MEA 2005, Wallace 2007). Additionally, the framework has proven to be a unifying construct among the public, decision-makers, and scientists since it communicates the environmental flow of ecosystem benefits to society in a common language (Granek et al. 2010). In other words, the framework provides a common unit of measurement among differing interest groups to elucidate tradeoffs that occur with different management options. Integrating scientifically assessed information and perceptions of stakeholders is a necessary step to progress ecosystem-based objectives in a given social-ecological system (Ostrom 2009). The ecosystem services concept may provide a means for this integration as it defines a common currency for decision-making (Granek et al. 2010).

To date, much of the ecosystem services research has focused on economic valuation of services for cost-benefit analyses, tools for operationalizing ecosystem services into

decision-making, and ecosystem services as a means of mainstreaming sustainable environmental management. The economic valuation of services developed as a means to articulate trade-offs (i.e., cost-benefit analyses) of competing plans of action (Costanza et al. 1997, Moberg & Folke 1999, Rönnbäck et al. 2007). Ecosystem service valuations can provide governing institutions with estimates of the monetary value of ecosystems, and research highlights that the value of these goods and services to human wellbeing is significant (Costanza et al. 1997). The methodologies for quantifying cost and benefits of ecosystem service values following this trend, however, is complex and remains controversial (Naidoo & Ricketts 2006). For example, standard environmental accounting methods for translating nonmarket benefits (such as willingness to pay or willingness to accept surveys) into market-based goods has been criticized for greatly overestimating the actual value of the benefit since the survey presents a hypothetical situation (Pearce 2007). It has also been argued that valuation studies fail to capture distributional equity and sustainability values (Howarth & Farber 2000).

In addition to the refinement of methods of market-based valuation of ecosystem services, more integrated tools, such as software programs, are being developed to help incorporate this framework into routine natural resource decision-making by quantifying production and flow of ecosystem services, and thereby establishing the impact of alternate policy scenarios on biophysical and economic models in tandem. For example, the Natural Capital Project, a partnership between Stanford University, The Nature Conservancy, and World Wildlife Fund, works to integrate conservation and the world economy by developing tools that include natural capital into decision-making. The

partnership has developed a software program, the Integrated Valuation of Environmental Services (InVEST), to facilitate this decision-making process for government agencies, non-profits and private corporations to both protect ecosystem health and improve livelihoods. The software starts the modeling process by consulting stakeholders to develop spatial scenarios of, for example, where climate change may affect precipitation regimes or sea level rise. Based on the stakeholder defined scenarios, the software projects future changes to ecosystem service location or production in a spatially explicit model. Modeled changes to ecosystem services can be expressed in both economic and biophysical terms (Daily et al. 2009). InVEST, and similar tools, allow decision-makers to model tradeoffs among alternative outcomes of decisions or policies that affect natural capital, and to map ecosystem services for the identification of priority conservation sites. Similarly, spatial modeling tools are being applied to conservation management strategies by using ecosystem service mapping to identify priority conservation sites and potential test beds for payments of ecosystem services (PES) (Daily & Matson 2008). It remains unclear whether these tools have transitioned into mainstream management practices due to complexities in scalability and consistency (Daily & Matson 2008). However, the dramatic increase in publications pertaining to applied ecosystem service management across diverse disciplines reveals a common interest to implement the framework into on-the-ground decision-making (Vihervaara et al. 2010). Although this area of study is increasing, it remains largely understudied (Gray et al. submitted 2013).

To date, perhaps the most unifying report on the status and refinement of the concept of ecosystem services comes from the Millennium Ecosystem Assessment (MEA) (MEA

2005). This international and interdisciplinary report provided a framework from which categorical definitions of the world's ecosystem services (provisional, regulatory, cultural, and supporting) were refined. The MEA outlined the current state and future trajectories of ecosystem services under status quo human behavior and management scenarios. The report also drew attention to the interconnected nature of humans and ecosystems by highlighting how unmonitored degradation of these services, has – and will continue to have – a negative feedback on human wellbeing. The MEA, in summarizing historical, present and future human and ecosystem relations, effectively unified and spurred ecosystem service research (Gómez-Baggethun et al. 2010, Vihervaara et al. 2010).

The MEA contributes significantly to the discussion of how ecosystem services are linked to discrete categories of human wellbeing (e.g., security, basic material for good life, health, good social relations, freedom of choice and action) by hypothesizing the strength of relationships between ecosystem services and factors influencing quality of life, and the ease at which these benefits can be mediated by socio-economic policies (Figure 1.1). Less is known, however, about how the links between social and ecological systems are defined and prioritized from a community perspective. Stakeholder involvement not only determines social values of ecosystem services and determines key ecosystem service management strategies, but may also help to generate public support to carry the plan into policy among environmental government and nongovernmental agencies (Iceland et al. 2008).

Environmental managers often represent constituents or stakeholder groups. As such, their mission and role as public stewards and their mission is highly invested in the outcome of decisions affecting both ecosystems and society. To understand linkages among ecosystem services and their societal benefits, the current study assessed how ecosystem services relate to human wellbeing from a natural resource management perspective (Figure 1.2). To analyze the implementation of the ecosystem service framework in on-the-ground management, assessing who is managing which ecosystem service may reveal gaps and overlaps in management. Addressing why ecosystem services are managed, in terms of promoting human wellbeing, may provide insight on monitoring how ecosystems both affect and are affected by society. Lastly, understanding how ecosystem services are managed may reveal the existence and effectiveness of current policy and decision-making for maintaining the links between ecosystem services and utility.

Of particular interest in the refinement of the ecosystem service framework is assessing the status of cultural ecosystem services (CES) – the nonmaterial benefits of ecosystems – in management decision-making, which has been particularly difficult. Although there has been a sharp increase in ecosystem service publications markedly since the MEA (Gómez-Baggethun et al. 2010, Vihervaara et al. 2010), CES remain the least understood type of ecosystem service compared to provisional, regulatory, and supporting services (Daniels et al. 2012). To some extent, CES have remained more difficult to incorporate into the ecosystem service framework because they are difficult to quantify and operationalize for management due to their nonmarket and often intangible nature (de

Groot et al. 2002, MEA 2005, Wallace 2007, Daniel et al. 2012, Chan et al. 2012a). Thus, the goals of the current study were to identify the management characteristics of CES, especially in comparison to provisional and regulatory services, and to empirically assess how CES relate to human wellbeing.

FIGURES

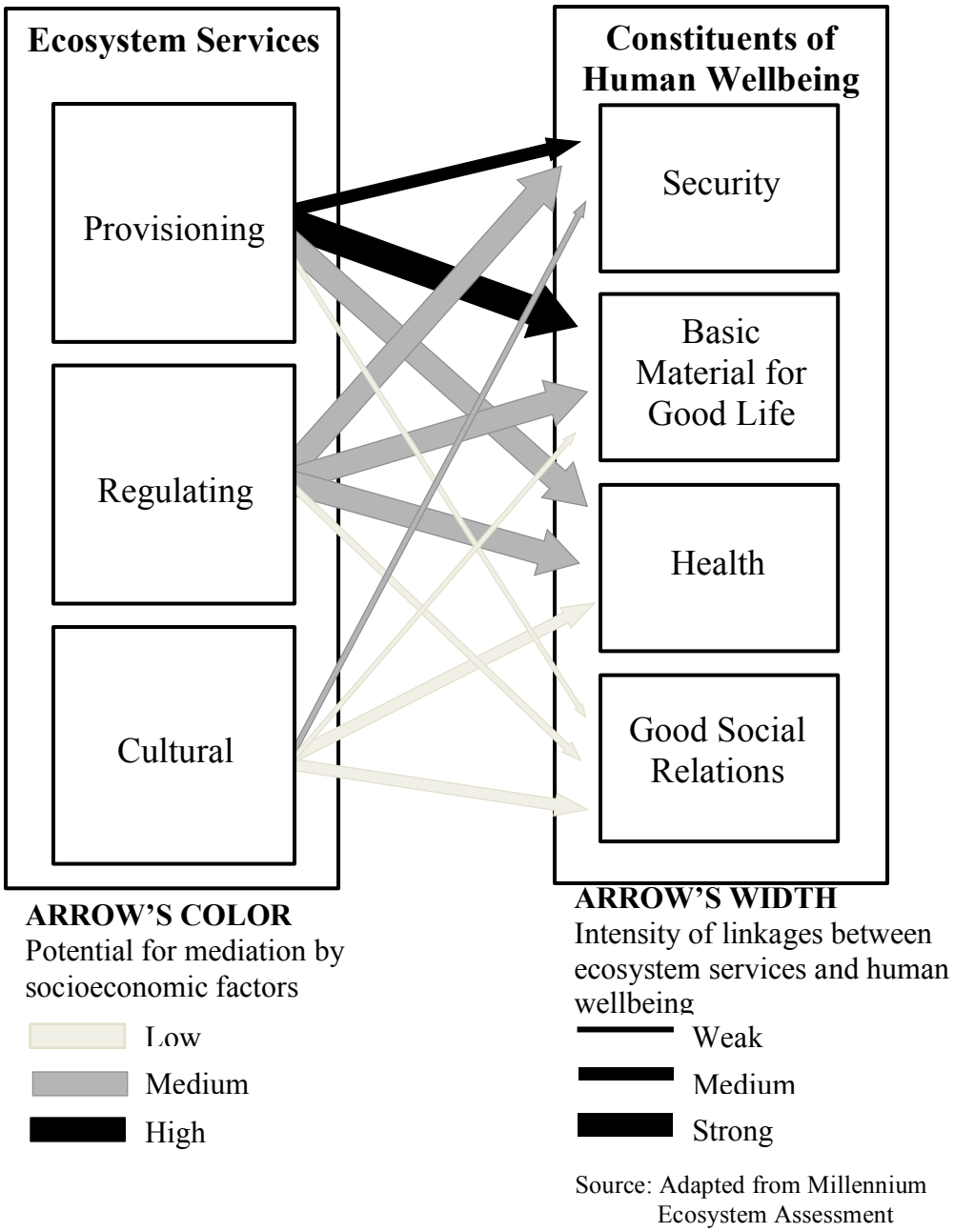

Figure 1.1 Theoretical linkages between ecosystem services and human wellbeing (modified from the Millennium Ecosystem Assessment 2005).

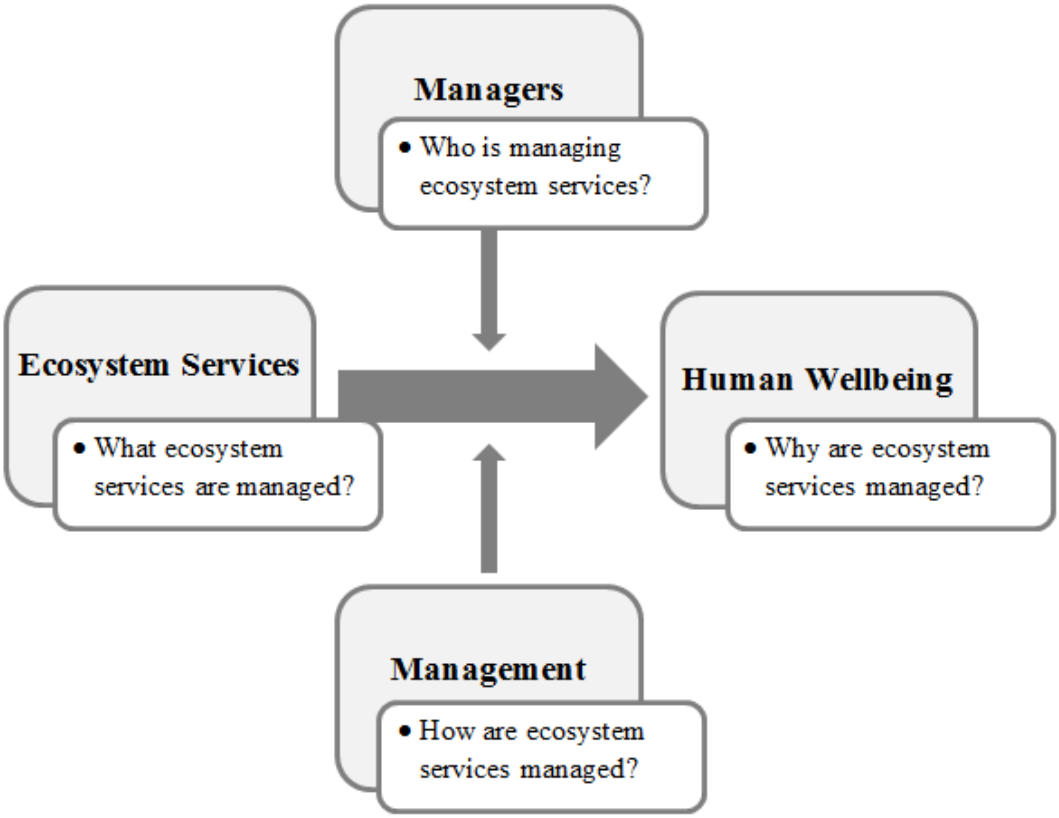

Figure 1.2 Conceptual diagram for ecosystem service management research.

CHAPTER 2

ANALYSIS OF CULTURAL ECOSYSTEM SERVICE MANAGEMENT IN HAWAII

1. INTRODUCTION

The ecosystem services concept has provided a means by which policy-makers, natural resource managers and other environmental stakeholders can communicate the relationship between ecosystem function and human utility (Daily et al. 2009). Brought into the mainstream in the late 1990s (see Daily 1997 and Costanza 1997) and further refined and operationalized by the Millennium Ecosystem Assessment (MEA) (2005), research into ecosystem services has suggested a conceptual structure for more comprehensive and holistic governance of social-ecological systems during a time of rapid environmental degradation. In light of the extreme extent to which humans have altered ecosystems through development and resource extraction, the MEA brought together scientists worldwide to discuss the need for a new framework to manage ecosystems into the future. These scientists found that while the exponentially growing use of ecosystem goods and services has increasingly benefitted humans, it has done so at the cost of degrading other ecosystem functions, worsening poverty among the rural poor, and diminishing opportunities for future generations. The MEA proposed the ecosystem services framework to address the problem of reversing the ecosystem degradation trend while also meeting increasing human demand. Additionally, the MEA suggested identifying how ecosystem services are related to human wellbeing and translating this linkage to values to inform decision-makers. To this end, the MEA defined the benefits humans receive from ecosystems in discrete categories, and proposed the strength of the relationships between human wellbeing and ecosystem service categories. These

proposed relationships are thought to provide a conceptual tool to value and manage the environment in value-laden terms. However, little to no information exists about the MEA relationships between ecosystem services and human wellbeing. In order to ground-truth the MEA in a specific, place-based context, the perception of ecosystem service managers regarding how ecosystem services are linked to human wellbeing is still needed.

In addition to empirical questions about the perceived relationships between ecosystem services and human wellbeing, there are also areas within the MEA proposed framework that have not been fully evaluated. For example, although cultural ecosystem services (CES) – the nonmaterial benefits of ecosystems – are an important component of the ecosystem service framework, research in this area has fallen behind regulatory and provisional services, and is an area that has chronically been understudied (Vihervaara et al. 2010, Gray et al. submitted 2013, Figure 2.1). Even though cultural ecosystem services are thought to contribute to important dimensions that maintain quality of life in human communities (MEA 2005, Chan et al. 2012a, Daniels et al. 2012), they remain difficult to incorporate into the ecosystem service framework compared to other services because they are difficult to quantify and operationalize for management (de Groot et al. 2002, MEA 2005, Wallace 2007, Daniel et al. 2012, Chan et al. 2012a).

Cultural ecosystem service research falls behind other categories of ecosystem service research because of three main reasons that include (1) difficulties in assessing CES value monetarily or biophysically, (2) their interrelated connectedness with other services, and (3) the absence of indicators to monitor their non-tangible effects on – or

direct contributions to – socio-ecological systems (MEA 2005, Granek et al. 2010, Atkinson et al. 2012, Chan et al. 2012a, Daniel et al. 2012). There are, however, an increasing number of studies that evaluate CES, which may help to better situate them into existing ecosystem service frameworks and decision-making (Daily et al. 2009, Fisher et al. 2009). For example, CES assessment techniques largely rely on stated preference (e.g., contingent valuation, conjoint choice) or revealed preference (e.g., travel cost method, hedonic pricing) methods of environmental accounting. However, these methods have been criticized for grossly overestimating the actual value of the benefit since the survey presents a hypothetical situation which presents difficulty in valuation (Pearce 2007). In addition, the CES's of recreation and tourism can be spatially modeled in software programs such as InVEST (Integrated Valuation of Environmental Services). Modeling tools are useful to improve the quantification of some CES (e.g., aesthetic value and recreation), but to date have failed to address CES such as heritage, education, and spiritual values because of the framework's reliance on monetary and quantitative analysis (Daily et al. 2009, Daniel et al. 2012). Although recent advancements in the theoretical underpinnings of CES have been made (Daniels et al. 2012), coupled with increases in proposed modeling techniques, questions still remain specifically with regard to the structural relationship between CES and human communities at different scales, how managers and scientists perceive their structural relationship to society and what CES are currently prioritized for management (NEA 2011, Atkinson et al. 2012).

Although CES are understudied, there have been important improvements in the integration of CES into the broader framework facilitated by new methods of stakeholder

participation in recent years. Stakeholder participation methodology has been suggested as a way to begin teasing apart how ecosystems relate to cultural values by having stakeholders define the contribution of ecological structure and function to CES production, relative to other ecosystem services (Chan et al. 2012a, Daniel et al. 2012). This engagement includes methods like discourse-based ecosystem service valuation through the use of small groups of stakeholders as a means of ecosystem service assessment that addresses the problem of social equity. As opposed to contingent valuation, deliberation-based valuation is a public process that is more suitable to CES since it evaluates these services as public goods and better reflects the social nature of the market (Wilson & Howarth 2002). Identifying priority ecosystem services among the public may also play an important role in meeting publically defined management objectives (Chan et al. 2012a), as demonstrated by the Puget Sound Partnership's efforts to develop an ecosystem service-based watershed restoration plan with goals and priorities determined by the broader community. Through interviews with a broad range of stakeholders, (Iceland et al. 2008), this study was able to determine the community's top five ecosystem priorities, among which recreation and existence values were regularly listed, which helped inform management strategies. Similarly, multi-criteria decision analysis has been used to determine ecosystem service priorities among the public to develop strategic management plans in the Murray-Darling Basin of Southern Australia (Bryan et al. 2010), which helped to operationalize diverse stakeholder perspectives in ecosystem service decision-making. Overall, community involvement not only determines social values of ecosystem services and determines key ecosystem

service management strategies, but may also help to generate public support to carry the plan into policy among government and nongovernmental agencies alike (Iceland et al. 2008).

Although the aforementioned methods contribute to an ongoing conversation, without indicators to monitor, assess, and address how CES influence and are influenced by socio-ecological systems or how management affects the ability of ecosystems to provide CES, it will be difficult to develop effective CES policies (Chan et al. 2012a). Thus, as a necessary first step to defining indicators of social or ecological change related to CES, the goals of the proposed study were to identify the management characteristics of CES especially in comparison to provisional and regulatory services and to empirically assess how CES relate to human wellbeing. To address these goals, the objectives of this study were to determine the following relative to other ecosystem services: a) what CES are being managed; b) why, or toward what human benefit, are CES being managed; and c) how CES are being managed.

2. METHODS

2.1 Study Area

To determine management characteristics of CES relative to other ecosystem services and identify how CES relate to human wellbeing, the study was conducted on the coastal and watershed ecosystems of the Main Hawaii Islands. The Main Hawaiian Islands offer an ideal model for investigating the current state of CES management since it is geographically and functionally bounded, and comprised of a diverse set of management agencies tasked with managing a range of ecosystem services for multiple and diverse stakeholder groups. Further, although the CES literature has focused mainly on terrestrial ecosystems (Gray et al. submitted 2013) (Figure 2.2), a significant number of non-material ecosystem services are derived from coastal ecosystems (Barbier et al. 2011), and coastal ecosystems are also consistently recognized as substantially contributing to spiritual, heritage, and education benefits, yet their nonmarket values remain difficult to assess (Moberg & Folke 1999, Rönnbäck et al. 2007, Barbier et al. 2011).

2 .2 Study Participants

Individuals solicited to take part in the study were natural resource professionals that worked with or for organizations that managed ecosystem services in Hawaii. Here, management is defined as researching, monitoring, decision-making, and/or providing outreach or education about ecosystem services.

Study participants were administered an electronic survey to address the first two objectives (i.e., what and why). In addition, survey participants were invited to engage in

a follow-up, semi-structured telephone interview, which was used to address the third objective (i.e., how). The survey contact list was presumed to be near-exhaustive based on the public record, and was developed to assess a diversity of job roles, government and nongovernment organizations (NGOs), and organization jurisdictions (local, county, state, federal and Pacific region, international) throughout the State (Maynard 2003, Carrier et al. 2012) currently engaged in natural resource management in various capacities (e.g., scientists, managers, outreach and education).

2.3 Electronic Survey Instrument

Prior to survey administration, a framework with 17 ecosystem services was developed based on a literature review (MEA 2005, Fisher et al. 2009, Haines-Young & Potschin 2010), and refined through two separate focus groups each consisting of more than 25 local experts in ecology and natural resource management (Table 2.1). The 17 different categories of ecosystem services are, for the purposes of this study, referred to as individual services (e.g., food from animals, climate regulation, recreation), and when combined into bins of services (e.g., provisional, regulatory, cultural) are termed aggregate services (Table 2.1). The supporting services category was removed from the final list used for the survey as this category is often conflated with other services (Wallace 2007, Haines-Young & Potschin 2010; Chan et al. 2012b).

The electronic survey consisted of two main parts: part one was used to meet study Objective A by assessing what ecosystem services are managed overall and which of these are management priorities based on the list of 17 individual services; and part two

addressed Objective B by asking participants to identify for what human wellbeing benefits they were managing ecosystem service priorities. The human wellbeing benefits were adopted from the Millennium Ecosystem Assessment's (2005) constituents of human wellbeing. The survey instrument included 16 questions (Appendix 1), using a multiple contact approach (three email survey prompts and one thank you letter) (Dillman 2007). Beginning on April 14, 2012, the survey was left open 19 days, and the schedule was developed to avoid federal and state government holidays. A question requesting information on nonresponse was included in the third email contact. To minimize response error, respondents were permitted to skip questions throughout the survey. Thus, the sample size for each question varied, with a maximum of 114 responses and a minimum of 78 responses.

2.4 Telephone Survey Instrument

In addition to the electronic survey to managers across the state, a separate follow-up telephone survey was conducted beginning on May 17, 2012 and collected over the course of 1 month. The telephone survey thus allowed respondents to clarify response from the mail-out survey. The survey instrument contained 19 questions (Appendix 2), and was developed to assess Objective C, how ecosystem services are managed. Semi-structured surveys took place immediately after the electronic survey was administered. Prior to distribution, both surveys were reviewed by the University of Hawaii at Manoa Institutional Review Board (IRB).

2.5 Respondent Socio-demographics

Overall the socio-demographics of the telephone survey population ($N = 35$) were similar to those of the electronic survey population ($N = 114$). No significant differences were found between the telephone and electronic survey respondents ($\chi^2(df = 2, N = 96) = 0.91$, $P = 0.636$), job role of respondents ($\chi^2(df = 2, N = 91) = 2.60$, $P = 0.272$), organization affiliation ($\chi^2(df = 1, N = 148) = 0.06$, $P = 0.801$), and organization jurisdiction ($\chi^2(df = 2, N = 148) = 2.15$, $P = 0.342$). The plurality of respondents from both the electronic (41.6%, $N = 113$) and telephone survey (48.6%, $N = 35$) groups worked for organizations with statewide jurisdictions, followed by federal jurisdictions (28.3%, 25.3% respectively) (Table 2.2). Both surveyed groups came from a variety of job roles, with the most frequent job role being other (38.1%, $N = 113$ electronic, 40.0%, $N = 35$ telephone) followed by natural resource managers (26.5% electronic, 25.7% telephone). Other job roles mentioned included, farmer, board member, data coordinator, both a manager and a scientist, and policy advocate. Lastly, the majority of respondents across both the electronic (70.8%, $N = 113$) and telephone (68.6%, $N = 35$) groups worked for government organizations (Table 2.2).

2.6 Data Analysis

Data from both surveys were analyzed using the Chi Square Goodness of Fit Test to assess differences in the expected versus observed distribution of data, and the Chi Square Test of Independence to compare the expected versus observed differences between two variables. The Fisher's Exact Test was performed when the Chi Square Test resulted in expected cell frequencies of >5 in contingency tables, and the Fisher-Freeman

– Halton Exact Test was used when expected cell frequencies of >5 occurred and contingency tables were greater than two by two. The decision criterion for significance was $\alpha < 0.05$.

2.7 Ecosystem Services Relationship to Human Wellbeing

To evaluate the perceived relationship between environmental managers in Hawaii and the hypothesized relationships provided by the MEA figure of how ecosystem services relate to human wellbeing for Hawaii's coasts and watersheds, respondents were asked three questions regarding: 1) their top ecosystem service management priority; 2) the connection this ecosystem service has to human wellbeing; and, 3) the degree to which they thought that socioeconomic policies were effective for sustaining the connection between the service and human wellbeing. Individual ecosystem services were combined three aggregate ecosystem services and human wellbeing benefits were combined into four aggregate wellbeing categories (Table 2.1).

To determine the intensity of linkages (line width) between ecosystem services and human wellbeing, each ecosystem service category was considered separately (cultural $N = 20$; regulatory $N = 14$; provisional $N = 20$). The width of connections between service category and benefit category were determined according to the percent of responses that identified the link, with 0% represented by no line, 1 – 33% of respondents was considered weak, 34% – 67% was considered medium, and >67% was considered high.

To determine the degree to which socioeconomic policies were effective in mediating the connections represented (line shading) each connection was considered separately. Similar to the line widths, the effectiveness of policy mediation was determined according to the percent of binary responses (e.g., agree effective or disagree effective) identified for each line based on questionnaire data. Line shading was assigned by evaluating the percent of agreement such that 1 – 33% that agreed to effectiveness was considered low, 34% – 67% that agreed to effectiveness was considered medium, and >67% that agreed was considered high.

2.8 Response Rate

In total, 281 emails were sent to environmental managers. When controlling for out of date email addresses ($N = 29$) and out of office replies ($N = 20$), the effective sample size was reduced to 232, and the response rate for the electronic survey was 49.1% ($N = 114$). For those environmental managers that did not respond to the electronic survey, only 10.2% responded to the nonresponse question posed in the third contact. In terms of nonresponse, respondents indicated that the survey was not applicable to their work ($N = 9$) or they had no time to participate ($N = 3$). The response rate for the semi-structured telephone survey was 30.7% based on those that self-selected themselves from the electronic survey ($N = 114$).

3. RESULTS

3.1 What cultural services are managed relative to provisional and regulatory services?

When asked to identify all the ecosystem services provided by Hawaiian coasts or watersheds currently managed by his or her organization from the provided ecosystem services list (Table 2.1), CES were most frequently managed overall, regardless of priority (45.2%, $N = 664$), followed by regulatory services (34.3%), and then provisional services (20.5%) (Figure 2.3). The average number of different ecosystem services managed per respondent was 6.9 ± 4.3 (SD; $N = 96$). An additional 32 respondents indicated that the list was either inapplicable or that they were managing other ecosystem services not on the provided list. Other ecosystem services mentioned included nature tourism, physical fitness, and coral reef conservation.

In terms of aggregate ecosystem service management priorities, environmental manager's top priorities were similar when categorized as provisional, regulatory, and cultural ($\chi^2(df = 2, N = 65) = 2.06$, $P = 0.357$) (Table 2.3). For the second and third management priorities, however, CES were the most frequently reported, followed by regulatory and then provisional services (χ^2 ($df = 2$, $N = 77$) = 19.51, $P < 0.001$; χ^2 ($df = 2$, $N = 76$) = 15.97, $P < 0.001$). Top management priorities of individual ecosystem services, however, differed significantly ($\chi^2(df = 12, N = 92) = 108.37$, $P < 0.001$). Science/education value was the top most frequently managed individual ecosystem service among both top management priorities (21.5%, $N = 65$) and managed services in general (11.3%, $N = 664$). Other frequently reported individual ecosystem service management priorities included food from animals (24.6%) and water quality control (18.5%).

The majority of NGOs (64.7%, $N = 17$, $P = 0.015$) and organizations with state jurisdictions (57.1%, $N = 35$, $P = 0.003$) manage CES as their top priority (Table 2.4). Regulatory services were never the most frequently listed top management priorities among organization affiliation or organization jurisdiction. Lastly, provisional services were most frequently selected as top management priorities among government organizations (39.6%) and organizations with federal jurisdictions (60.0%) (Table 2.4).

3.2 Why, or toward what human benefit, are cultural services managed relative to provisional and regulatory services?

The primary aggregate benefit for which top ecosystem service priorities of Hawaii's coasts and watersheds were managed varied significantly among environmental managers ($\chi^2(df = 3, N = 70) = 11.49$, $P = 0.009$), with the most frequently selected being security (35.7%), followed by basic material for good life (30.0%), health (25.7%) and lastly, good social relations (8.6%). The top individual benefits managers recognized as important for managing top ecosystem service priorities were secure resource access (22.9%), sufficient nutritious food (18.6%) and access to clean water (17.1%) (Table 2.5).

When placed in the context of the MEA's (2005) conceptual figure for top ecosystem service management priorities among environmental managers in Hawaii, the reasons for managing CES were more varied than regulatory and provisional services (Figure 2.4). CES were the only service to be managed for all four categories of human benefit given. However, the majority of CES were managed for security (50.0%, $N = 20$). The remaining CES were managed for health (20.0%), good social relations (20.0%), and

basic material for good life (10.0%). The majority of regulatory services were managed for health (64.3%, $N = 14$) with most of the remaining regulatory services being managed for security (28.6%). No regulatory services were managed for good social relations and only one respondent managed these services for basic material for good life. Provisional services were primarily managed for the human benefit of basic material for good life (85.0%, $N = 20$). The remaining provisional services were managed for security (15.0%). Thus, no provisional services were managed for the benefits of health or good social relations (Figure 2.4).

When considering individual services and benefits, the strongest link from a CES to a benefit was from science/education value to secure resource access, with 20.0% of respondents who managed CES as their first priority in agreement. For individual regulatory services, the strongest link was from water quality to access to clean water (64.3%). Lastly, for provisional services, respondents managed the individual service food from animals for the benefit of sufficient nutritious food most frequently (50.0%) (Figure 2.4).

There was disagreement among respondents about the effectiveness of the socioeconomic policies that currently exist to sustain cultural, regulatory, and provisional services. Specifically, for CES, 45.0% ($N = 20$) of respondents agreed policies were effective whereas 42.9% ($N = 14$) of respondents agreed for regulatory services, and for provisional services 45.0% ($N = 20$) agreed (Figure 2.4).

3.3 How are cultural services managed relative to provisional and regulatory services?

The majority of CES were managed as public goods (70.0%, $N = 10$), although 20.0% were managed as both public and private goods, and only one CES was managed as solely a private good (Table 2.6). Conversely, the majority of regulatory services were managed as both public and private goods (63.6%, $N = 11$). An additional 27.3% were managed as entirely public goods, and only one regulatory service was managed as solely a private good (Table 2.6). Lastly, provisional services were primarily managed as public goods (70.0%, $N = 10$), and the remaining were managed as both public and private goods (Table 2.6).

In terms of what policies guide management of ecosystem services, respondents whose top management priority was a provisional service could articulate the most policies, while few respondents who managed regulatory and CES could clearly articulate policies. Overall most of the policies mentioned for managing ecosystem services were federal (90.9%, $N = 11$) (Table 2.7). Unarticulated policies included phrases such as "state law regarding food products," "any county policies," "state and federal guidelines," and "mandates concerning watershed protection."

Only one respondent could articulate policies regarding CES out of the ten respondents who listed a CES as their top management priority, and this respondent listed both the National Historic Preservation Act and the Endangered Species Act (Table 2.7). Approximately a third of respondents could articulate policies regarding regulatory services (27.3%, $N = 11$), including the Water Resources Development Act and the Clean

Water Act (Table 2.5). In contrast, most respondents could clearly articulate policies regarding provisional services (70.0%, $N = 10$). Policies listed included Magnuson-Stevens Act, Endangered Species Act, National Environmental Policy Act, Marine Mammal Protection Act, Coastal Zone Management Act, and the Migratory Birds Act and Acts of the Inter-American Tropical Tuna Commission (Table 2.7).

There was agreement among all respondents that CES were managed at the state level. However, the scale at which they were benefitting humans was evenly split among the state/county/local level (50.0%,), and the international/Pacific island community (50.0%) (Figure 2.5). Specifically, the individual CES of heritage/ indigenous value and recreation value were the services that were managed locally, but benefitted internationally. For regulatory services, respondents agreed that these services both managed and benefited humans at the state/county/local level (36.4%, $N = 11$) or the Pacific island/international level (36.4%) (Figure 2.5). Finally, for provisional services, there was agreement among respondents that these services were both managed at and benefited humans at the Pacific island/international level (50.0%, $N = 10$) (Figure 2.5). While 40.0% thought there was a mismatch between management jurisdiction and beneficiaries, these mismatches were associated with the food from animals ecosystem service and likely relate to international commerce.

4. DISCUSSION

In Hawaii, CES are a high management priority among the environmental management community, especially among nongovernmental organizations and agencies with state jurisdictions. CES are linked primarily to security, with a specific focus on science and education value. Furthermore, CES are largely managed for public good, and although they are often place-based, CES managed on a local scale may benefit others internationally. Despite the importance of managing CES in Hawaii, articulation of specific policies in place to manage these services is nearly nonexistent, and the effectiveness of CES policy remains controversial, and is likely highly dependent on the individual service managed.

These findings therefore identify a major gap in CES management because although these services are clearly valued by the majority of the management community, policy mechanisms are not necessarily readily available or at least brought to mind by resource managers. The gap identified in this study parallels other cultural assessments where the value of CES is consistently recognized without a means to account for them (Moberg & Folke 1999, Rönnbäck et al. 2007, Barbier et al. 2011). Defining structural relationships and indicators to monitor how CES affect human utility and how management affects the ability of ecosystems to provide CES can offer a means of forming strategic management plans and policies (Chan et al. 2012a). Here, management characteristics of CES were identified that can allow researchers a starting place to develop operative indicators.

4.1 Characteristics of Cultural Services

4.1.1 Characteristic 1: Managers of Cultural Services

Environmental managers were asked to identify characteristics of their management of ecosystem services as they often represent constituents or stakeholder groups. Because of their role as public stewards their mission is highly invested in the outcome of decisions affecting both ecosystems and society. Since CES were primarily managed as public goods, community input will continue to be important to developing meaningful indicators.

Local, county and state agencies, as well as NGOs focused their management primarily on CES, and were less concerned with provisional services. In contrast, regulatory services were managed almost equally among government and NGOs, and provisional services were the focus of management for governmental organizations with federal jurisdictions. The importance of local NGOs in managing CES is substantiated by the finding that all CES were managed on the local, county or state level, and thus are place or regionally specific. NGOs in Hawaii play an important role since each island in the state is relatively isolated, and has different political and social climates. Consequently, many environmental agendas are locally driven and island-specific. Grassroots movements throughout the nation have become particularly well-known for setting environmental regulation priorities, and mobilizing local community members to prevent environmental degradation (Karan & Suganuma 2008). In Hawaii, grassroots efforts have been fueled by both mid-management level environmental professionals and local community volunteers to remove invasive species that threaten both Hawaii's

biodiversity and native culture since many native plants, such as taro, are considered sacred by indigenous Hawaiian culture (Jasparro 2008). Further, traditional Hawaiian resource management is place-based and focuses on community and ecosystems rather than political boundaries (Tissot et al. 2009). Overall, for successful identification of CES indicators and implementation into effective decision-making, grassroots and bottom-up management may be the foundation of maintaining CES. Accordingly, they may be key informants to defining CES indicators.

4.1.2 Characteristic 2: Cultural Services Relationship to Human Wellbeing

The MEA's illustrated hypothesis on how ecosystem services are linked to discrete categories of human wellbeing provided the framework for answering why ecosystem services are managed in Hawaii. Based on environmental managers' top ecosystem service management priorities and perceptions regarding why they were managing ecosystem services, the MEA's suggested strength of the links between ecosystem services and human wellbeing were empirically tested in this study (Figure 2.4).

In general, the MEA's hypothesized relationships were similar to how Hawaii's environmental managers perceived them to exist with several unique aspects. First, in terms of perceptual relationships from resource managers, the data suggest a weaker relationship between provisional services and health benefit than proposed, and a weaker relationship from regulatory services to the basic material for good life benefit. These weaker relationships are likely due to the MEA's global focus, considering the ecosystem services throughout the world as a whole, including many developing countries where

food is not so readily imported. Thus food security depends on local ecosystem provisions which, when threatened, leads to an overall health decline of the surrounding community who may not have the economic resources to import food. Environmental managers in Hawaii, a developed state where basic provisions are largely met, may not suffer many health consequences from lack of provisioning services given their economic security. Second, the largest individual ecosystem service within the regulatory category was water quality control. Thus the focus on health for water quality, rather than basic material for good life, makes sense within this context. Most interestingly, the relationship between CES and security benefits were stronger than predicted which may be caused by threats to the vulnerability of traditional native Hawaiian way of life, the threats of climate change to aesthetic values and the need for science and education to progress to protect Hawaii's diverse ecology with more research and as a means of generating economic revenue.

CES were managed primarily for the human wellbeing benefit of security, and thus assessing community security may be crucial to monitoring socio-ecological change related to CES. Also, CES were the only services that were managed for every category of benefit (security, health, basic material for good life, and good social relations) – a reminder of their diffuse nature and interrelation with other services. In comparison, provisional and regulatory services relationships to benefits were more straightforward and showed less variation in response. CES, overlapping with other categories of services in their production, may also yield multiple benefits from a single service (Atkinson et al. 2012).

There are many threats to native Hawaiian cultural security through high rates of tourism and population increase, the high rate of invasive species introductions, and climate change threatening the coastal indigenous way of life (DBEDT 2006, Pimentel et al. 2005, Salick & Anja 2007). With Hawaii's tourism increasing steadily since the 1940's and hosting 7 million visitors in 2011 alone, tourism is Hawaii's primary economic industry. Tourism as a whole generates $11.2 billion annually, nearly 17% of Hawaii's total economy (DBEDT 2011). Tourism, however, is a double-edged sword in that the commodification of culture and ecosystem amenity value can improve economic viability while also diminishing their ability to procure those profits into the future (Gladstone 2005). Given their traditional and contemporary importance, understanding CES and their management is an important component to developing effective management strategies which allow these areas to mitigate unwanted environmental change (Barbier et al. 2011, NEA 2011) if they are expected to be included as part of routine natural resource management. Lastly, culture has been found to help bind social relations together against environmental and economic hardship, providing a means of social resilience (Adger et al. 2013).

Science and education value was a highly managed individual ecosystem service among environmental managers, which could be attributed to Hawaii's high biodiversity that attracts scientists and students to study its unique ecology. Hawaii's isolation in particular provides a laboratory to investigate questions about evolutionary biology (Eldredge & Evenhuis 2003) and the small scale impacts of global environmental change (Loope &

Giambelluca 1998). For example, Hawaii's coral reef system provides habitat to some 8,000 species of marine plants and algae and 680 fish species (Eldredge & Evenhuis 2003). The link between science and security could be associated with Pacific islands' vulnerability to the effects of climate change due to their high ratio of shoreline to land area, remoteness from continental landmass, dependence upon primary production, and sensitivity to the impact of rising sea levels (Barnett 2001). As environmental organizations throughout the state prepare for the impending effects of future climate change, scientific education regarding natural systems becomes ever more important. Finally, in order to track CES change over time will require investing in both science and education. It is proposed that in being able to identify CES change will influence environmental and conservation decision-making to increase environmental security.

4.1.3 Characteristic 3: Cultural Ecosystem Service Management Scale Relative to Beneficiaries Scale

Although CES are locally managed, respondents agree that these services benefit humans at both the local and the international scale. This finding holds particularly true for heritage/indigenous value and recreation value. Preserving indigenous value associated with the environment may benefit at the international scale because international tourists can participate in or view indigenous traditions when visiting the Islands. In 2011, for example, an average of 80.0% of travelers to the Islands from Hawaii's primary source regions of tourists (contiguous United States, Japan, Canada, Europe and Oceania) participated in cultural activity or visited cultural sites (historic site, museum/art gallery, Polynesian show/luau/hula, play/concert, art/craft fair, parks/gardens, festival, other sites)

(DBEDT 2011). In terms of recreation value and ecotourism, people who visit Hawaii often enjoy the natural environment through many outdoor activities such as snorkeling, diving and surfing (Cesar & van Beukering 2004, DBEDT 2011). Additionally, the finding of Hawaii CES benefitting beyond their scale of management was echoed by the National Oceanic and Atmospheric Administration (2011) in a report regarding the Hawaiian Islands Humpback Whale National Marine Sanctuary Management Plan Review. This review held a 90 day public comment and scoping period to establish the sanctuary whereby people in Hawaii, other states and the international community could comment on the posed management of the sanctuary, specifically taking an ecosystem-based management approach with the inclusion of marine resources not specifically related to humpback whales that could be protected within the reserve. The public scoping period drew more comments from outside of Hawaii (6,311) than from within the state (6,015). The comments from outside of Hawaii primarily came from a Marine Conservation Biology Institute (MCBI) online petition (98.3%), indicating a conservation and existence value ecosystem service provided by the whales at the national and international scale given the largely non-market value of humpbacks whale conservation. Additionally, the report surmised that Native Hawaiian Perspectives and Ocean Access and Uses were two of the four overarching considerations from the comments, where Ocean Access included resident ocean recreation, which given reduction in travel and access costs fall far behind tourist revenue and access costs. Consequently, CES indicators may need to include social impacts at an international scale, especially for tropical islands and areas with indigenous communities.

In comparison, provisional services were found to be both primarily managed and benefited humans at the international scale, which is likely due to international commerce and fishing regulations. Scale of management and benefit mostly aligned for regulatory services at two different scales: managed at local, county or state scale and benefitted humans at this scale or managed at the international scale and benefitted humans at this scale. The variable findings concerning the characteristics of regulatory ecosystem services indicate the difficulty that they pose to management agencies. Services, such as climate change control, are a concern to many environmental organizations throughout the State, and yet the global scale of the climate change poses a management hurdle. Similarly, the international coordination required to manage some regulatory services impedes successful policy.

4.2 Cultural Service Indicators – A Way Forward

Recently, new means to quantify CES and their benefits have been suggested as a means to track CES's influence on human wellbeing over time. It may well begin with community-based assessments of the contribution of ecological structure and function to CES production (Daniel et al. 2012), stakeholder discourse-based ecosystem service valuation (Wilson & Howarth 2002), and multicriteria decision analyses (Bryan et al. 2010). Other revealed preference accounting methods have also been proposed as methods to monitor the CES contribution to human utility. For example, legacies, such as charitable donations, have been offered as a way to account for non-material benefits of ecosystems (Atkinson et al. 2012). Environmentally-related scholarship funding, in particular, could point to the value of science and education provided by ecosystems. As

CES are most often place-based, bottom-up management and community input may be the most informed by the values of CES (Adger et al. 2013), and socially-determined ecosystem service priorities may also engender local public support (Iceland et al. 2008).

Environmental managers in Hawaii may manage CES for security because these services can enhance cultural and environmental resilience. In Hawaii, many people traverse ecological and cultural edges – transitioning and interacting across ecosystem types and cultural groups in their daily lives. This interaction fosters adaptive capacity in the socio-ecological system as a whole since a wider variety of natural resources and knowledge systems are available to use in the face of change and disruption (Turner et al. 2003). Capturing CES security, in particular, could be assessed through indicators of social and ecological resilience. Functional diversity has been suggested as an indicator of ecological resilience (Costanza et al. 1995), while an array of indicators could be used to capture community adaptive capacity such as household occupational multiplicity, capacity to anticipate change and respond, and community infrastructure (McClanahan et al. 2008). Adaptive capacity indicators of different social-ecological systems may also be developed through qualitative approaches such as historical investigations, participant observation, and cultural narratives. Lastly, community mental models may inform indicators as well as adaptive management strategies of CES (Adger et al. 2013). As the ecosystem service framework progresses from the literature into on-the-ground management, CES cannot be left behind, but to incorporate them fully into the ecosystem framework will require consideration of diverse social science techniques grounded in community-defined values.

TABLES

Table 2.1 Aggregate and individual ecosystem service categories of Hawaii's coasts and watersheds.

Aggregate Ecosystem Service	Individual Ecosystem Service
Cultural	Aesthetic value Spiritual value Recreation value Heritage/indigenous value Science/educational value
Regulatory	Water quality control Air quality control Erosion control Storm/wave mitigation Pest control Disease control Climate control
Provisional	Food from plants Food from animals Raw materials from plants Raw materials from animals Raw materials from minerals

Table 2.2 Respondent demographic information of the electronic (N = 113) and telephone surveys (N = 35).

Respondent Profiles		
Jurisdiction of Organization	Electronic Survey (%)	Telephone Survey (%)
Municipal/Local	8.0	11.4
County/Island	4.4	5.7
State	41.6	48.6
Pacific Region	12.4	8.6
Federal	28.3	25.7
International	5.3	0.0
Job Roles		
Researcher/Scientist	23.9	14.3
Natural Resource Manager	26.5	25.7
Outreach/Educator	11.5	20.0
Other	38.1	40.0
Organizational Affiliation		
Governmental	70.8	68.6
Non-governmental	29.2	31.4