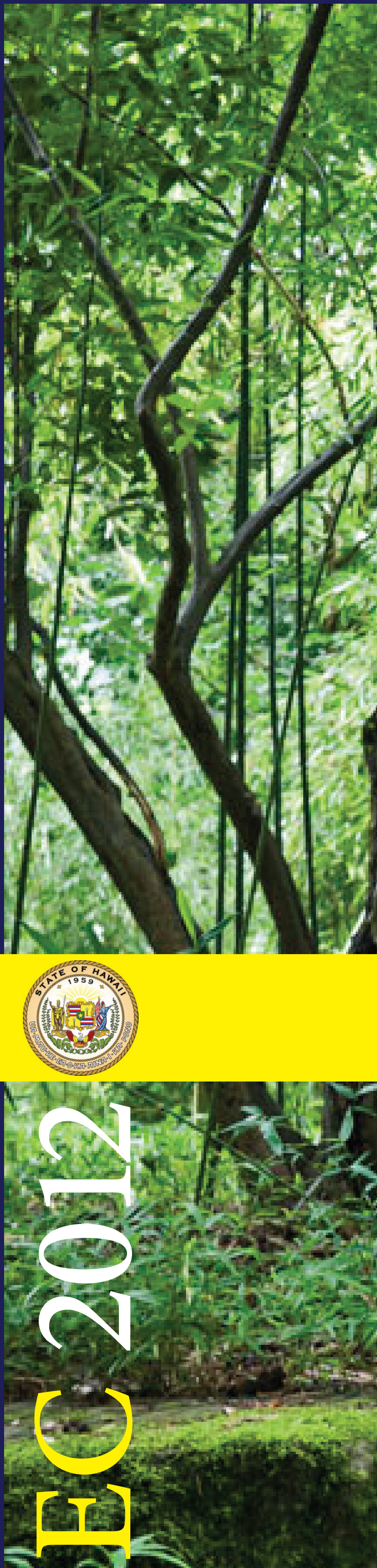


HAWAIʻI STATE ENVIRONMENTAL COUNCIL
ANNUAL REPORT

EC 2012

towards a green ECONOMY

Introducing
THE GPI TO HAWAIʻI

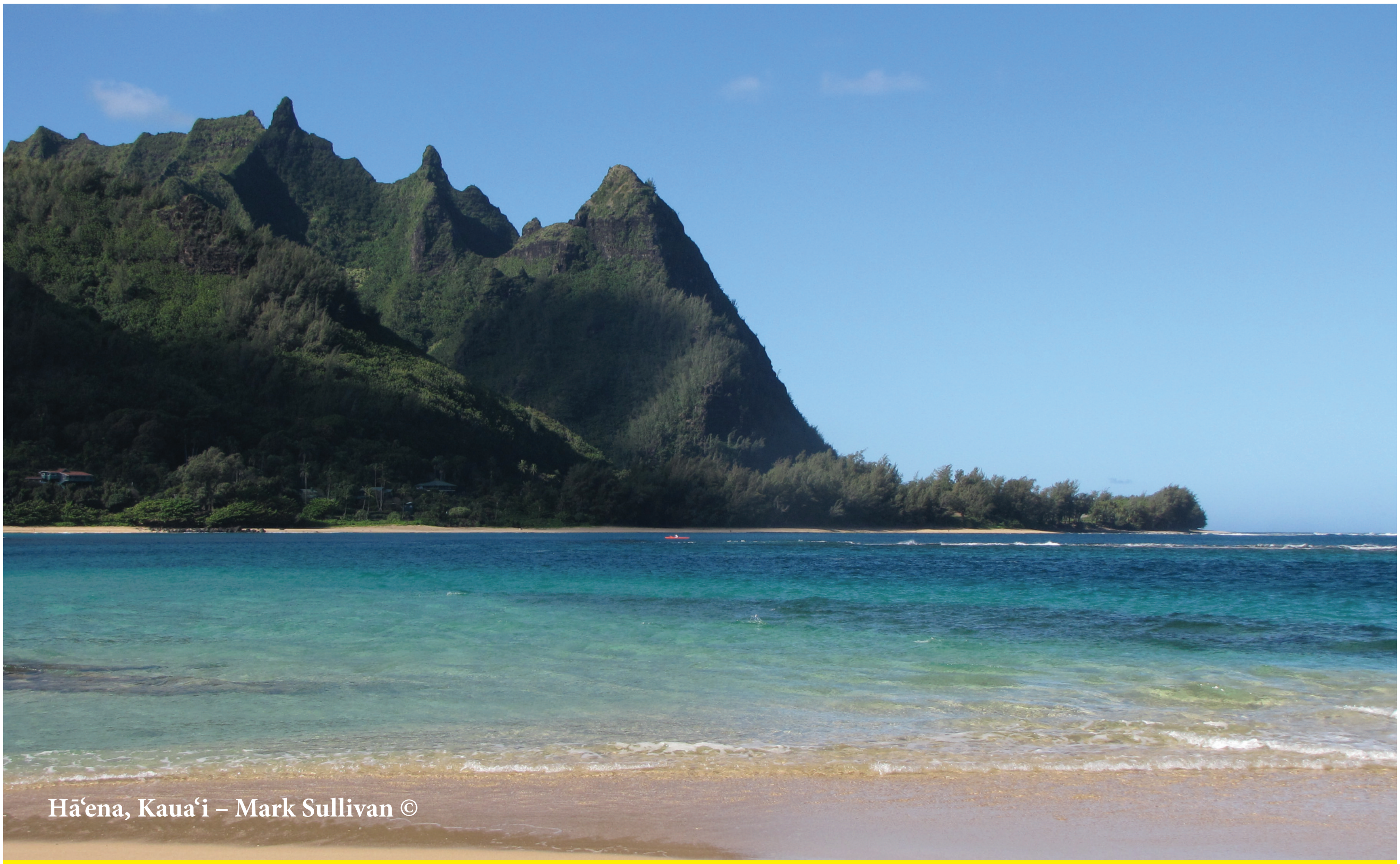
please read this Eco-Friendly Message

—save a Tree

Mahalo for considering your environmental responsibility before printing. This report should be printed double-sided and viewed as a booklet with facing pages. It is also available online at http://hawaii.gov/health/environmental/oeqc/index.html/

"Hahai no ka ua i ka ululāʻau.
Rains always follow the forest."
– Mary Kawena Pukui
ʻŌlelo Noʻeau: Hawaiian Proverbs & Poetical Sayings
Bishop Museum Press, 1983

Hawaiʻi Volcanoes National Park, Hawaiʻi – Greg Cope ©



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2012

Kahakuloa, Maui – Forest & Kim Starr ©

Turtle Bay & Kawela Bay, Oʻahu – Courtesy of Keep the North Shore Country

Neil Abercrombie
Governor

Loretta J. Fuddy
Director
Department of Health

Gary L. Gill
Deputy Director
Department of Health

Annual Report

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Gary L. Gill (Ex Officio)
Malia Akutagawa
Mark R. Ambler
David Atkin
Scott Glenn
Koa Kaulukukui
Shannon Mears
Charles Prentiss
Azita Quon
John Richards
Iris Terashima
Glenn Teves
Marjorie Ziegler

Molokaʻi Coastline – Malia Akutagawa ©

JANUARY 31, 2013

Hinahina & Kaunaʻoa – Forest & Kim Starr ©

Acknowledgments

This report is the result of collective efforts of many individuals. Special recognition and thanks to Dr. Regina Ostergaard-Klem of the Hawaiʻi Pacific University, and Dr. Kirsten Oleson from the University of Hawaiʻi for providing their technical expertise for this year's focus topic *Towards a Green Economy: Introducing the GPI to Hawaiʻi*. Thanks to their team of graduate students, James Cogswell, Marcus Peng, and Danielle Lien, whose work made the development of the this topic possible.

Many thanks to Dr. David Penn from the University of Hawaiʻi Environmental Center, Anna Kelly from the Office of Environmental Quality Control, and Laura McIntyre from the Department of Health for providing extensive research and data support. Thanks to the Hawaiʻi Department of Business, Economic Development, and Tourism and Department of Land and Natural Resources for providing data. Thanks to Scott Glenn for planting the seed for this year's topic, Malia Akutagawa for mobilizing the technical team, Azita Quon for designing the graphics and visual context, the photographers for their amazing images, and Marjorie Ziegler, Helga Jervis, and the OEQC staff for their production assistance. Last, mahalo nui loa to Gary Gill for his support and broad vision for Hawaiʻi.

It is with great pleasure that the Environmental Council submits its 2012 Annual Report to the Governor, the Hawaiʻi State Legislature, and the public.

"ʻAʻohe hana nui ke alu ʻia"
No task is too big
when done together by all.

– Mary Kawena Pukui
ʻŌlelo Noʻeau: Hawaiian Proverbs & Poetical Sayings
Bishop Museum Press, 1983

Photographers

Malia Akutagawa, Bruce Behnke, Jeff Berkes, Greg Cope, Ron Gingerich, Hiʻipaka LLC, Jack Jeffrey, Jody Kaulukukui, Keep the North Shore Country, Victoria Martocci, Kukui Maunakea-Forth & MAʻO Organic Farms, Rob Shallenberger, Forest & Kim Starr, Mark Sullivan, Evan Tector, Kaneko Uchino, Rick Warshauer, Anita Wintner, Yvonne Yarber Carter


Manu O Kū – Forest & Kim Starr ©

Regina Ostergaard-Klem

Associate Professor
Global Leadership and Sustainable Development
College of Natural and Computational Sciences
Hawai'i Pacific University

Regina Ostergaard-Klem holds a Ph.D. in Systems Analysis and Economics for Public Decision Making from The Johns Hopkins University. She is an Associate Professor of Environmental Science in the College of Natural and Computational Sciences at Hawai'i Pacific University.

Dr. Ostergaard-Klem teaches in both the Environmental Science/Studies program at the undergraduate level and the master's program in Global Leadership and Sustainable Development. Her teaching is concentrated in the fields of environmental economics, ecological economics, industrial ecology, environmental policy, and natural resource management. Given her interests in sustainability and urban environmental management, she is currently involved in construction of a rain garden on the Hawai'i Loa campus. Her research interests are focused on alternative measures for social welfare, and the nexus between the two disciplines of ecological and environmental economics.

Dr. Ostergaard-Klem was a Fulbright Fellow in Poland, during which time she conducted research for her dissertation. After completing her Ph.D., she was a Science and Diplomacy Fellow for the American Association for the Advancement of Science in Washington DC. Prior to moving to Hawai'i, she worked as an environmental policy advisor at the US Agency for International Development, working on urban environmental and energy programs globally.

Kirsten L.L. Oleson

Assistant Professor
Ecological Economics
Department of Natural Resources &
Environmental Management
University of Hawai'i

Kirsten Oleson is an Assistant Professor of Ecological Economics at the University of Hawai'i Mānoa. She holds a Ph.D. from Stanford's Interdisciplinary Program in Environment and Resources. Prior to joining the University she was a Fellow with Stanford's Public Policy Program, a National Science Foundation Postdoctoral Fellow studying social-ecological systems in Madagascar, and a World Bank staff member.

Natural capital, such as land, water, and biodiversity, supports human well-being, yet this crucial capital is depleted and degraded because it is generally unaccounted for in standard decision-making frameworks. Dr. Oleson's research addresses this by integrating economics and the environment along three related tracts:

- Building "green accounting" methods to improve the metrics we use to signal economic "progress." These accounting tools seek to include environmental and social changes, e.g., loss of forested land or gains in education, rather than myopically focusing on the economy's productive sector. They also aim to track global impacts of consumption.
- Linking watershed-scale ecological modeling with economic models to assess the outcomes of resource development alternatives.
- Studying coastal communities' natural resource management.

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Kailua Beach, Oʻahu - Jody Kaulukukui ©

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This report entitled *Towards a Green Economy: Introducing the GPI to Hawai'i* highlights the special topic of the Genuine Progress Indicator (GPI). GPI is a measure of social welfare that was developed in 1995, and complements the traditional measure of Gross Domestic Product (GDP). While GDP measures economic growth, GPI is a more holistic measure of economic, social, and environmental factors. GPI adjusts GDP by deducting environmental and societal costs, such as pollution or depletion of non-renewable resources, that result from that growth.

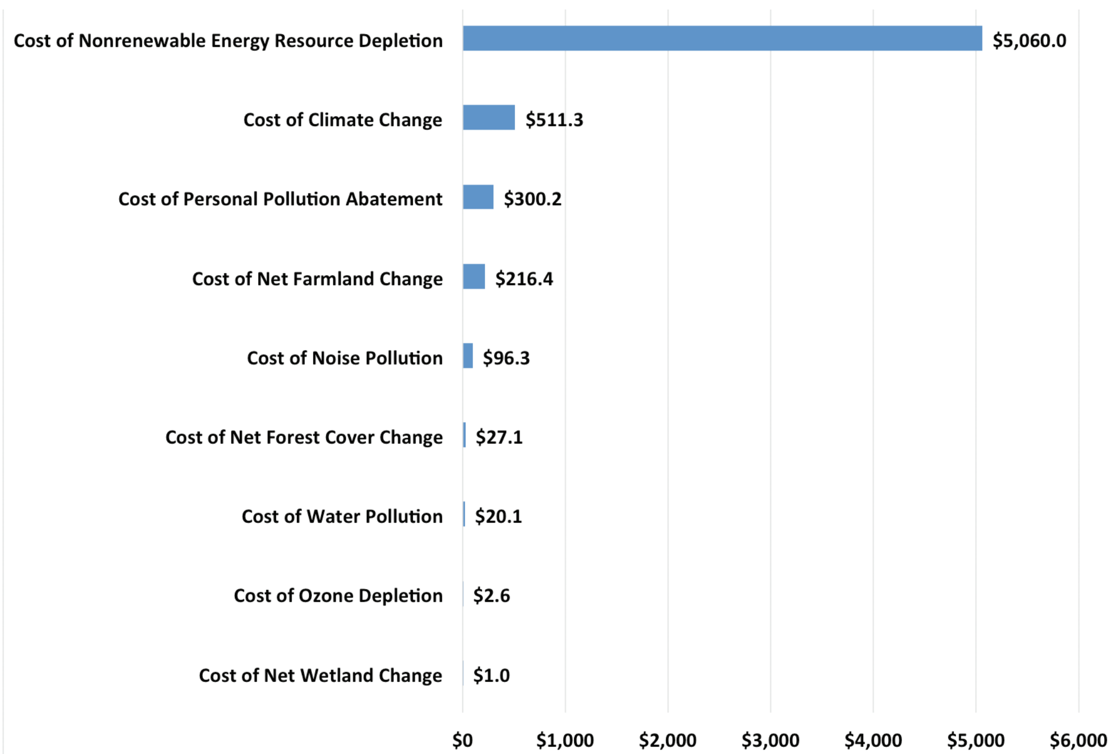
Currently, nine applications of GPI exist at the national, state, and/or county level within the US. Hawai'i offers a unique and remarkable context in which to further demonstrate the policy relevance and benefits of GPI. So to further explore this possibility, in August 2012 we formed a working group consisting of members from Hawai'i Pacific University, College of Natural and Computational Sciences (HPU CNCS) and University of Hawai'i, Department of Natural Resources and Environmental Management (UH NREM). This report showcases the initial phase in the HPU-UHM team's application of GPI to the state of Hawai'i. The HPU-UHM team plans to expand and refine this baseline GPI model over the coming years, with the long-term goal of moving towards greener and more sustainable accounting practices and decision making for Hawai'i.

Approach

The GPI model tracks a set of twenty-six economic, environmental, and social indicators. For our baseline survey, we used the platform provided by the Maryland GPI, the first state government-led GPI initiative and the most comprehensive application to date. Of the twenty-six indicators, we concentrated our initial efforts on only those ten indicators that reflect environmental changes, such as water pollution, land use changes, personal pollution abatement, and replacement of non-renewable resources. We used readily available, publicly accessible data at the state and local level when available, or proxy data at the national level when needed. We surveyed the literature for relevant valuation studies, particularly those related to Hawai'i, and adopted valuations specific for the state when possible. For each indicator, we matched the biophysical measures of environmental change with dollar estimates of the cost of those changes based on prior valuation studies. The result is a dollar amount for each environmental indicator, making it possible to see trends and relative costs across indicators and gain a sense of the magnitude of cumulative costs.

Findings

The figure below shows the relative costs across nine environmental indicators (we chose to exclude air pollution costs in the initial phase) using a base year of 2000. According to GPI calculations, in 2000 the state faced environmental degradation estimated at over $6.2 billion (2000 USD), or close to $6,000 per capita for that year. Of the estimated total, $5.1 billion can be attributed to the depletion of nonrenewable energy resources. The disproportionate distribution highlights the fact that Hawai'i is one of the most oil-dependent states in the nation. This number underscores the environmental and social cost of nonrenewable energy such as fossil fuels instead of renewable sources such as wind and solar.



Environmental costs in year 2000 [million 2000 USD]

In addition, average costs were calculated for each of the environmental indicators for the time series of data available. These results reinforce the relative magnitude of costs across indicators as well as the disproportionate contribution of the depletion of non-renewable resources.

Most of the indicators trend upwards in costs over the years for which data were available. For example, the cost of noise pollution has risen as Hawaiʻi has urbanized; costs to avoid pollution have risen as population has grown; and more costs have been incurred each year due to increasing farmland loss since 1984 and forest loss since 2001. A notable exception to this persistent upward trend is ozone, for which costs have gradually approached zero due to international policy phasing out ozone-depleting substances.

Conclusions

Our provisional findings show that economic growth in the productive sectors of the economy, which is what is typically reflected in GDP (and similarly Gross State Product or GSP at the state level), comes at a cost of environmental depletion and degradation. Furthermore, the findings show the relative magnitudes of these typically unaccounted for costs.

We used the GPI framework to locate numerous sources of data across state and federal agencies, and compiled the data to form a baseline inventory. This baseline will be the foundation for a full-fledged GPI exercise in the coming years. While this exercise has gathered some initial data on many of the key components of GPI, it also revealed a number of data and knowledge gaps. For those data gaps identified, we defined related research needs. Further efforts will seek to find sources of not only the biophysical measures associated with the changes to the environment, but also the monetary values related to those environmental goods and services. Ideally, the data to fill those gaps will exist or be generated at the local level.

While we believe that GPI provides useful and relevant information for numerous reasons, we acknowledge some shortcomings in our preliminary results due to limitations of the model. Because the model uses data from various sources with varying degrees of certainty, we agree that this is not a precise number. Instead, the model is used to paint a more complete picture of trends in social welfare and environmental conditions that are not otherwise captured in measures such as GDP. Assigning dollar values to non-market goods like those provided by the environment is inherently difficult, yet relative values are inadvertently incorporated into the decision making process regardless of this difficulty. The GPI model strives to use the best peer-reviewed and locally relevant valuation studies available.

Other issues arise because of the scope of this first phase. We focused only on the environmental indicators. The data we gathered vary in quality and availability across time. Furthermore, we used Maryland as the platform for our work in Hawaiʻi. To address these issues, our future efforts will utilize the complete model by incorporating social and economic factors. Data will be better estimated across time periods. Further refinements will strengthen the local Hawaiian context by adding indicators of environmental and cultural significance and striving to locate and/or generate more data locally. For example, we propose adding a new indicator for coral reefs to capture their economic, cultural, and environmental significance in Hawaiʻi. By adopting local valuations, excluding mainland costs not applicable to Hawaiʻi, and adding representation for ecosystems unique to the state, we are confident in GPI's applicability and relevance to Hawaiʻi.

Recommendations

Our preliminary results include the illustration of policy relevance, development of a data repository, identification of data trends as well as gaps, and recommendations to further refine the model and the data that feed into it. Based on these results, the HPU-UHM team recommends the following actions:

- Disseminate the results of the first phase of GPI-Hawaiʻi;
- Complete the remaining components (both social and economic) within the GPI framework;
- Further refine the components of the GPI model to better reflect local priorities and conditions;
- Search for applicable data and evaluation studies that are generated locally;
- Connect GPI to other Hawaiʻi initiatives and priorities;
- Use the framework of GPI to engage Hawaiʻi state agencies and other stakeholders in data collection; and
- Encourage Hawaiʻi state agencies to look more holistically at their goals (environmental, social, and economic) and refine them if needed.

a message from the Annual Report Committee

Endangered Hala Pepe, Kona, Hawai'i – Yvonne Yarber Carter ©

We are pleased to present the 2012 Hawai'i State Environmental Council Annual Report, which provides a snapshot of the issues, challenges, and accomplishments of the Environmental Council (EC) and the Office of Environmental Quality Control (OEQC) in monitoring the progress of state, county, and federal agencies in achieving the state's environmental goals and policies.

The protection of our environment is critical for sustaining Hawai'i for future generations. This report includes highlights of various initiatives supporting the environment and improving the implementation of Hawai'i Revised Statutes Chapter 343, which the EC and OEQC hope to move forward in the coming year.

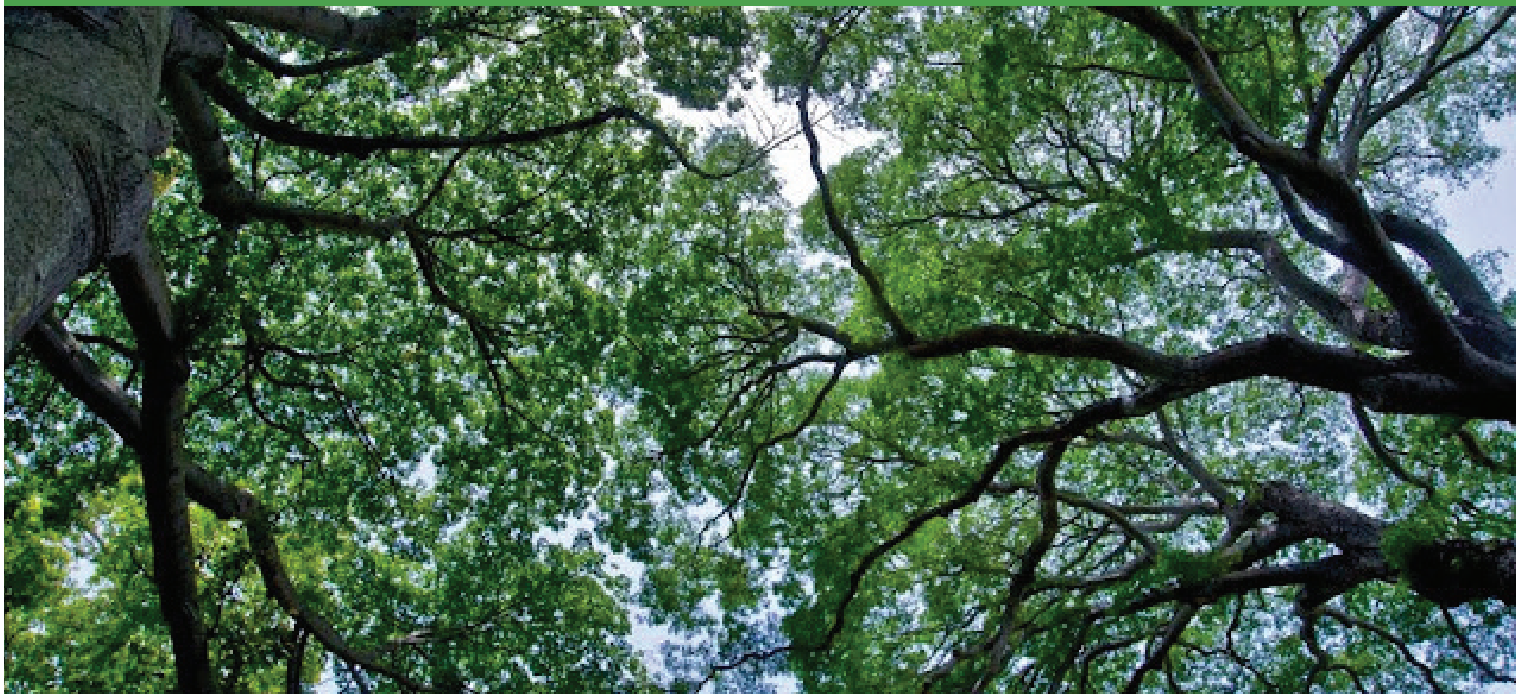
The subject of this year's annual report is green accounting utilizing Genuine Progress Indicators (GPI). We worked with Professor Regina Ostergaard-Klem from Hawai'i Pacific University and Professor Kirsten Oleson from the University of Hawai'i to bring their special focus and cutting-edge research to your attention.

It is our hope that this 'pilot study' lays the foundation for a standardized method for measuring the true health of the economy; an innovative process to incorporate economic, environmental and social factors; a visioning for future data collection and environmental accounting; and a valuable policy evaluation and potential budgeting tool. Green accounting using GPI provides opportunities for collaboration between government agencies, academia, the private sector, and the public to improve the quality of our environment.

Much Aloha,
Malia Akutagawa
Azita Quon

2012 Annual Report
Committee Chairs

introduction to the Environmental Council



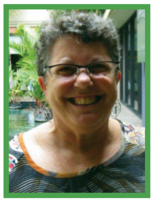
Old Trees – Bruce Behnke ©

Purpose of the Annual Report

The Environmental Council (EC) and the Office of Environmental Quality Control (OEQC) were created in 1970 and codified under Hawai'i Revised Statutes (HRS) Chapter 341. The purpose of HRS Chapter 341 "is to stimulate, expand and coordinate efforts to determine and maintain the optimum quality of the environment of the State." This annual report is provided in compliance with HRS Chapter 341-6: "The council shall monitor the progress of state, county, and federal agencies in achieving the State's environmental goals and policies and with the assistance of the director shall make an annual report with recommendations for improvement to the governor, the legislature, and the public no later than January 31 of each year."

The Environmental Council

The Environmental Council shall serve as liaison between the Director of the OEQC and the general public on issues concerning "ecology and environmental quality." The EC consists of 14 dedicated and conscientious volunteers appointed by the Governor and confirmed by the Hawai'i State Legislature, and the Director of the OEQC, who serves as an ex officio member. Members of the EC represent "a broad and balanced representation of educational, business, and environmentally pertinent disciplines and professions, such as the natural and social sciences, the humanities, architecture, engineering, environmental consulting, public health, and planning; educational and research institutions with environmental competence; agriculture, real estate, visitor industry, construction, media, and voluntary community and environmental groups." (HRS 341-3 (c)) The EC holds HRS Chapter 343 rule-making powers. It also reviews and provides concurrence on agency exemption lists. The EC may make recommendations concerning ecology and environmental quality to the Director of the OEQC.

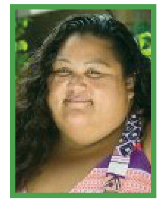


Mary Steiner, Chair

Mary Steiner has chaired the Environmental Council since 2010. She recently left The Outdoor Circle after 20 years as its CEO and now serves as the Hawai'i Campaign Manager for the non-profit Compassion and Choices, an organization that works to improve care and expand choice at the end of life. Mary's goals with the Environmental Council include helping OEQC to obtain proper levels of funding, providing support to the Rules Committee to update and revise the rules, and demystifying the environmental review process so that the grassroots, project proponents, and developers alike are able to understand the procedures and not fear them. Mary strongly believes that a strong economy goes hand-in-hand with a healthy environment and one doesn't have to be at the expense of the other. She said, "I have never worked with such dedicated individuals as this year's council members. Each member is willing to roll up his or her sleeves and jump right in. They make my job as chair fun and easy."

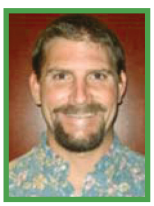
Gary Gill, Acting Director OEQC

Gary Gill was born and raised in Honolulu and educated in the Hawai'i Public School system. He served on the Honolulu City Council for two terms, including two years as Chair. In 2011, Governor Neil Abercrombie appointed Gary as Deputy Director for the Environment in the Department of Health. Gary previously served as the Director of the OEQC and as Department of Health's Environmental Deputy during the Cayetano administration. He is currently Acting Director of the OEQC. Prior to returning to state government, Gary worked in various non-profit community organizations, including the Sierra Club, Kōkua Kalihi Valley and Blue Planet Foundation. Gary and his wife, Susan, have been married for 25 years. Their daughter, Lorin, is attending the American University in Washington, DC, and their son, Darian, is in the 8th grade at Kawānanakoa Middle School in Honolulu.



Malia Akutagawa

Malia Akutagawa is currently with the University of Hawai'i at Mānoa William S. Richardson School of Law – Ka Huli Ao Center for Excellence in Native Hawaiian Law and Hawai'inuiākea School of Hawaiian Knowledge. She is also the President and Founder of Sustainable Moloka'i, a non-profit focusing on creating an environmentally, economically, and culturally sustainable island that serves as a model for Hawai'i and the world. She was Director of the Moloka'i Rural Development Project, which provides workforce training and supports rural economic development initiatives in collaboration with the University of Hawai'i, and public, private, and non-profit partners. Malia worked as a reviewer with the Environmental Center and as an attorney with the Native Hawaiian Legal Corporation. She contributes to the Council through her legal expertise and background as a Hawaiian cultural practitioner with a strong affinity for the 'āina.

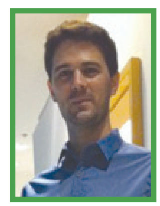


Mark R. Ambler

Mark Ambler has been a member of the Environmental Council as of May 2012. Born and raised in Kailua, Hawai'i, he received degrees from 'Iolani High School and the University of Illinois at Urbana-Champaign. Mark's career has been devoted to pursuit of innovative and sustainable environmental engineering. He is a Professional Engineer registered in the State of Hawai'i and a Project Management Professional. These certifications represent a history of technical and leadership training as well as professional experience. He has championed implementation of sustainable concepts, such as Green Roofs and Green and Sustainable Remediation in Hawai'i, and has had the opportunity to share those positive examples across the country. "I don't agree with use of the environmental review process as a tool initiated by special interest groups to impede smart planning and development. Rather, I see it as an opportunity to properly prepare for and mitigate all of the factors that are effected by the action."

David Atkin

David Atkin has been an environmental planner for over 30 years, the last 20 of which have been in Hawai'i. David sees the State's environmental review process as essential, but is concerned that, "its implementation doesn't match our current circumstances." David posits that we may well be "living at the start of a new geological period, the 'Anthropocene,'" marked by "tremendous change wherein the consequences of past environmental practices will be increasingly evident." David is Chair of the Environmental Council's Exemption Committee. He sees his role as helping the Council to focus on substantive issues regarding the environment to "achieve a more responsive system."

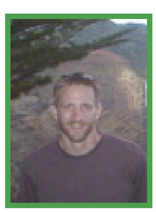


Scott Glenn

Scott Glenn is an environmental planner at Cardno TEC, Inc. He received his Master's Degree in Urban and Regional Planning from the University of Hawai'i in 2009, where he was a graduate assistant for the statewide study of Hawai'i's environmental review process. He specializes in environmental review and climate change adaptation planning and lends his expertise as Chair of the Environmental Council's Rules Committee. Scott is leading the Council's current effort to modernize the EIS administrative rules.

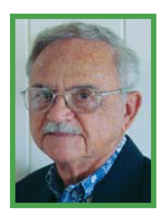
Koa Kaulukukui

Koa Kaulukukui, Esq., was raised in Puna on Hawai'i Island. Koa earned her Bachelor of Arts Degree through University of Hawai'i's Environmental Center and a Juris Doctorate and Certificate in Environmental Law from the William S. Richardson School of Law in 2006. She has since worked as an associate attorney for Earthjustice and a policy advocate for the Office of Hawaiian Affairs. She currently assists with managing OHA's landholdings and focuses on ceded land issues. As a member of the Environmental Council, Koa hopes to help shape environmental policy that ensures a robust future for our keiki without compromising the cultural and natural resources of our islands.



Shannon Mears

Shannon Mears, Esq., is a graduate of Brigham Young University - Hawai'i and the University of Hawai'i William S. Richardson School of Law. Currently, Shannon works as a Research Attorney for the Legislative Reference Bureau at the State Capitol. Shannon hopes to bring his legislative drafting skills to the Environmental Council's Rules Committee to make the environmental review process clear and predictable for all stakeholders. As a member of the Council, Shannon feels it is a privilege and responsibility to first and foremost protect the environmental health of Hawai'i while ensuring the economic ability of its people to remain here into perpetuity.



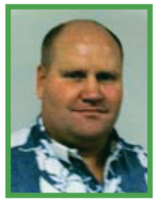
Charles Prentiss, Ph.D.

Charles Prentiss is an urban planner, city manager, and a retired city planner with the City & County of Honolulu. He holds degrees in economics, city planning, and government management. He is a former Executive Secretary of the Honolulu City Planning Commission, a Vietnam veteran pilot, and a retired Lieutenant Colonel of the Hawai'i National Guard. Chuck is also President of Hawai'i's Thousand Friends and Chairperson of the Kailua Neighborhood Board. Chuck's professional experiences motivate him to promote environmental protection. He possesses a strong belief in the necessity for citizen participation in government. For him, "Participation aids in government openness and honesty, and provides a countervailing force to special interests in government decisions. In Hawai'i, the environment is our economy."

environmental Council

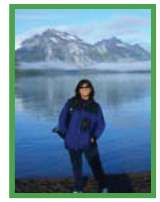
Azita Quon

Azita Quon has a broad range of architectural experience in Hawai'i and the Pacific Rim in the areas of master planning, design, and architecture of hospitality, and high-rise mix-use residential, educational, courthouse, and institutional buildings. She is a licensed architect and a LEED Accredited Professional with a Master's Degree in Business Administration from the University of Hawai'i. "As an architect, I understand the complex relationship between architecture and the natural environment. The built environment impacts how we live and the quality and well-being of our community. It is so critical that the two co-exist and integrate harmoniously. I am excited about the future of design with green initiatives and approaches to development and architecture. There is a great momentum for a green and sustainable Hawai'i and I am excited to be a part of it."



John Richards

John Richards was born and raised on a cattle ranch on the Big Island of Hawai'i. He has been intimately involved with agriculture and natural resource management for most of his life. John has lived in different parts of the world for both schooling and military service, which lent him a unique perspective on sustainable land and resources use. As the sixth generation of his family in Hawai'i, John has very deep roots and a desire to see the islands thrive. For him, "The Council offers the opportunity to help the systems that protect the islands. A careful balance must be found to ensure business has what it needs to function well, while protecting the spirit, lands and people of Hawai'i. Laws and their application can either make us greater or limit our potential. The Council has the opportunity to facilitate the former."



Iris Terashima

Iris Terashima is a licensed engineer and principal of ITES, a Honolulu-based consulting firm specializing in environmental risk management. She is a "local girl" (graduate of Waiālua High School), with degrees in Chemical Engineering and Information Systems, and has worked as an environmental engineer in Hawai'i and the Pacific for over 20 years. She shares an enthusiasm for service on the Environmental Council and wants to do her "share and 'pull with the team' to protect Hawai'i's environment for future generations."

Glenn Teves

Glenn Teves has been a County Extension Agent with the University of Hawai'i College of Tropical Agriculture and Human Resources on Moloka'i for the last 30 years, where he provides technical assistance to farmers and organizations on Moloka'i. He presently serves on the boards of the University of Hawai'i Professional Assembly and the Moloka'i Community Services Council. He is actively involved in water and land use issues on Moloka'i, and was a member of the Water Working Group convened by the Department of Land and Natural Resources and the Maui Community Plan Review Advisory Committee. He is a Hawaiian Home Lands farmer in Ho'olehua and grows banana, taro, and assorted fruits and vegetable for the local market. "What makes Hawai'i special are its people, its island communities, and its unique environment. These are intertwined and are part of a whole, and must be nurtured and protected. This only comes through deliberate and diligent planning."

Marjorie Ziegler

Marjorie Ziegler joined the Environmental Council in 2011. She grew up, and still lives in Kāne'ohe, O'ahu. She has worked in the non-profit, environmental sector for the past 30 years, including The Nature Conservancy of Hawai'i, Earthjustice (previously Sierra Club Legal Defense Fund), KAHEA: The Hawaiian-Environmental Alliance, and, since 2003, as Executive Director of the Conservation Council for Hawai'i. CCH is a membership organization established in 1950 and dedicated to protecting native Hawaiian plants, animals, and ecosystems for future generations. Marjorie brings a grassroots activist and wildlife conservation perspective to the Council.

the OEQC

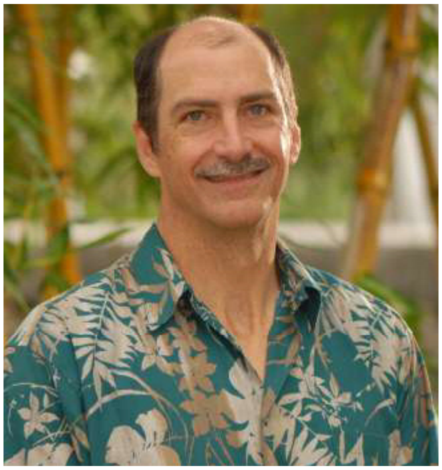
The Office of Environmental Quality Control (OEQC) was established in 1970 to help stimulate, expand and coordinate efforts to maintain the optimum quality of the state's environment. The OEQC implements Hawai'i Revised Statutes (HRS) Chapter 343, which governs the environmental review process. Office planners review hundreds of environmental disclosure documents and respond to thousands of inquiries each year from both the public and the private sectors. Twice a month, the OEQC publishes The Environmental Notice which announces the availability of Environmental Assessments and Environmental Impact Statements undergoing public review. The OEQC staff also provides support to the Environmental Council regarding amendments to the administrative rules, exemption lists, and the Council's annual report. The OEQC is attached to the Hawai'i Department of Health for administrative purposes.

OEQC staff (left to right) Leslie Segundo, Environmental Health Specialist, and Herman Tuiolosega, Planner.

The OEQC Director provides advice and assistance to private industry, government agencies, and community groups regarding HRS Chapter 343. The agency is also empowered by law to conduct research, develop legislative initiatives, do public outreach, and recommend programs for the long-range implementation of environmental quality control.

Planner Genevieve G. Hilliard joined the OEQC in 2012.

a report from the OEQC Acting Director



This was a year of real progress for the Office of Environmental Quality Control. Under the leadership of Gary Hooser, the basic functions of the environmental review process were sustained and improved. Staff revised the guidebook that helps the public, private applicants, and government agencies navigate the law, rules, and procedures of environmental disclosure. We sponsored workshops to train and educate stakeholders in the environmental review system. Improvements were made to the Environmental Notice to make it easier to read and understand. The office supported the smooth functioning of the Environmental Council as this hard-working team of volunteers tackled its work reviewing and approving exemption lists, revising the rules, crafting this annual report, and other tasks. Goals and strategic actions were identified in a professionally facilitated retreat for staff and council members.

As summer ended, Gary Hooser stepped aside as OEQC Director to successfully pursue a different form of public service as a member of the Kaua'i County Council. In his absence, I have been temporarily assigned to manage the office.

During my time as acting director, we have permanently hired new planning staff and solidified the office team. We have begun efforts to dramatically improve the look and functionality of The Environmental Notice. We are seeking funds to take the next step in information technology that will make all environmental review documents available and searchable in a digital library.

In early 2013, we expect that Governor Abercrombie will appoint a new director for the office and this momentum of progress will continue with each new day.

With Aloha,

Gary Gill

Deputy Director
Environmental Health Administration
Hawai'i State Department of Health

a report from the Environmental Council Chair

Where does the time go? The Environmental Council had a busy and extremely productive year. The Exemption Committee has cleared its backlog of exemption requests and is moving forward with its recommendations on revisions to the rules as they affect exemptions. The Rules Committee held several long and fruitful meetings, at which committee members reviewed the current rules and discussed proposed revisions. The Rules Committee has held several long and fruitful meetings where its members review the current rules and discuss proposed revisions. They are doing a fabulous job by attempting to reach a diverse group of consultants, agencies and advocates in order to develop clear and concise rules. Both of these committees provide notice of their meetings, and the public is invited to participate.

The Council also has instituted some changes. After our summer retreat, we added another committee. The purpose of the Information/Outreach Committee is to communicate to the public and agencies issues about 343 compliance. This committee is in its infancy, and I am excited to report that you will be hearing more about it over time. In addition, we have invited the University of Hawai‘i's Environmental Center to be a regular participant at our monthly meetings. David Penn, Environmental Center faculty, has been helpful and active. He provides updates about the Center's work, offers input to the Exemption Committee on proposed exemption list revisions, and is helping the Rules Committee. We are all grateful for the Environmental Center's help.

This year's annual report committee, working with Professor Regina Ostergaard-Klem from Hawai‘i Pacific University and Professor Kirsten Oleson from the University of Hawai‘i, has brought an entirely new focus and cutting-edge research to this report. I hope you find the information on Genuine Progress Indicators as interesting as I do. Working on the annual report is a difficult task, and our committee has been wonderful in bringing it to fruition.

We receive support from many sources. Our Deputy Attorney General, Edward Bohlen, has played a helpful role by advising me when I am not sure how to proceed. And I would be remiss if I didn't give a huge mahalo to both Gary Hooser and Gary Gill. "The Garys" have been supportive throughout the year. When Gary Hooser went on leave to run for a position on the Kaua‘i County Council, Gary Gill stepped up. And finally I would like to thank the OEQC staff. In addition to providing administrative help, they are always available to council members for discussion and feedback. Of course, the staff also speaks to members of the public on topics concerning environmental quality. Have a question? Just give them a call.

In conclusion, this year has been an active and busy one for the Environmental Council. It gives me great pleasure to conclude that each council member brings a diverse point of view, is dedicated and willing to set aside personal agendas, and is entirely committed to maintaining the integrity of the environmental review process. I want to thank each of you and tell you know how much I appreciate the work you are doing. You make my job easy. Mahalo nui loa!

With Aloha,

Mary Steiner, Chair, Environmental Council

a report from the Rules Committee Chair

2012 highlights

Koʻoloaʻula – Ron Gingerich ©
Koʻoloaʻula is an endangered shrub found in native dry forests on Maui, Lānaʻi, and Hawaiʻi.

Scott Glenn

In 2012, the Rules Committee released its first draft of proposed changes to Hawaiʻi's EIS rules, Hawaiʻi Administrative Rules (HAR) 11-200. The draft is a first step. It is the result of a year of consultation the Rules Committee and Environmental Council conducted with the public and state and county agencies. These stakeholders identified a range of issues that have become critical in the functioning of the environmental review process. Among these issues are cultural impacts, supplemental environmental impact statements, and public participation in the process.

After the Rules Committee released the draft, stakeholders offered a range of comments on the proposed language, the reasoning for the proposed language, and alternative approaches.

The Rules Committee thanks everyone who has participated to date, sharing their manaʻo, and especially their patience.

In 2013, the Rules Committee will continue working on revising the administrative rules. It is reviewing the comments it received and will reassess its approach and proposed language. It intends to release a revised draft in Summer 2013 for the public and government agencies to review and comment on. Following this, it will consider revisions before beginning the process to formally update the administrative rules.

ʻŌhiʻa Lehua – Forest & Kim Starr ©
The distinctive shape and vibrant colors of the ʻōhiʻa lehua add to the rich biological tapestry of native plants and animals in Hawaiʻi.

a report from the Exemption Committee Chair

David Atkin

The major goals of the Exemption Committee this year have included the processing of exemption list modifications appropriately and with stakeholder involvement, and also working on suggested improvements to the exemption process for referral to the Rules Committee.

The Exemption Committee had a very busy 2012. We met 11 times and considered three exemption proposals this year from: the Department of Land and Natural Resources for geothermal exploration; the City and County of Honolulu Department of Environmental Services; and the County of Kauaʻi Department of Public Works and Department of Parks and Recreation. In addition to processing exemption list proposals, we spent several meetings discussing improvements that could be made to the existing rules pertaining to the exemption process. The kinds of issues discussed included public notification of exemption determinations, whether a project must appear on an agency's exemption list to be exempt, duration of an exemption determination, and the creation of a new exemption class for projects that are beneficial to the environment. The committee recommendations will be provided to the Rules Committee in early 2013.

Goals for the coming year include support of rule changes to improve the exemption process and continued attention to exemption list modifications submitted.

ʻŌlulu - Forest & Kim Starr ©

The endangered ʻōlulu, sometimes referred to as "cabbage on a stick," is one of the most unusual and interesting plants of the Hawaiian flora. Its Latin name means "remarkable." ʻŌlulu has a thick, succulent stem and is crowned by a rosette of leaves with a cream to yellow cluster of flowers, which has a fragrance that resembles mild honeysuckle.

Hibiscus Kokio – Forest & Kim Starr ©

ʻOhai – Forest & Kim Starr ©

Mark R. Ambler

The Environmental Council approved the establishment of the Information and Outreach Committee on November 15, 2012 based on the discovery of its need to increase public outreach and strengthen stakeholder involvement during interviews and discussion at the June 28, 2012 retreat.

The purpose of this committee will be to communicate to the public and agencies Environmental Council issues and Hawaiʻi Revised Statutes Chapter 343 requirements (excluding legislative bills, which remain in the purview of the Legislative Committee). By providing a structure for public interface, we will be able to survey community concerns and increase outreach to the stakeholders. The committee will look at increasing opportunities with media, use of social media, outreach to less populated areas, and by having a presence at conferences.

In 2013, the committee looks forward to developing goals, policies, and strategies. Three council members have volunteered to serve on the committee and are excited about the opportunity to identify and coordinate different methods of outreach and initiate positive change.

ʻĀwikiwiki – Forest & Kim Starr ©

ʻIʻiwi – Jack Jeffrey ©

The ʻiʻiwi was once one of the most common native forest birds in Hawaiʻi, but this spectacular bird has disappeared from most of its former range and may be listed as an endangered species.

ʻElepaio – Jack Jeffrey ©

The ʻelepaio is the guardian spirit of the kahuna kalai waʻa (canoe builder). In traditional times, if he observed an ʻelepaio perched and pecking on a koa tree, it was thought that the tree was filled with insects and was not a good selection for a canoe.

Palila – Jack Jeffrey ©

The American Bird Conservancy has made the palila one of its high-priority species for bird conservation work in Hawaiʻi. The endangered palila, which once lived throughout the Hawaiian Islands, is now clinging to less than 5% of its range on Mauna Kea on the Big Island of Hawaiʻi. ABC's goal is to increase the palila population to at least 2,000 birds by 2023, by fencing and restoring its core breeding habitat, and engaging in aggressive predator control. The two major factors affecting the palila population are degradation of natural habitat by introduced sheep and goats, whose heavy grazing prevents regeneration of the bird's native māmane forest habitat and predation by introduced predators.

Introduction

Gross Domestic Product (GDP) is used to measure economic activity within a nation as well as provide a standard for comparison of economic growth across nations. GDP was originally developed solely as an indicator of economic health, but over time its association with social welfare has grown. An increase in GDP is now inextricably linked, whether implicitly or explicitly, with an increase in social welfare. Yet criticism from economists and policy makers alike has raised considerable awareness of GDP's inability to capture the nuances of social welfare and wellbeing.

GDP is an incomplete measure of social welfare

GDP, and similarly Gross State Product (GSP) at the state level, measure the value of all goods and services that are produced by an economy within its borders during a year. While increases in GDP are generally associated with the "healthy growth" of an economy, the measure fails to account for many of the external costs of that growth. Externalities like pollution can result in human health impacts and the degradation of ecosystems services. Associated costs (such as defensive expenditures to avoid the negative impacts of pollution or clean-up costs following environmental disasters) actually add to GDP because those expenditures contribute positively to economic activity. In addition, because GDP is calculated on a yearly basis and focused only on the short-term, it does not account for depreciation costs of either the man-made or natural capital expended to increase economic growth. Moreover, non-market costs that impact social welfare, like loss of leisure time, are not captured at all in GDP.

Although GDP lacks the ability to capture social welfare, and was never meant for such a purpose, the measure continues to play a critical role in today's policy making. Yet as awareness of GDP's limitations has grown over the last few decades, so has the effort to develop alternative measures to GDP. Building upon efforts since the 1970s, the public policy think tank Redefining Progress introduced the Genuine Progress Indicator (GPI) in 1995 (Talberth, et al., 2007). GPI belongs to a category of alternative indicators using accounting adjustments to GDP to correct for deficiencies.

GPI is a more complete measure of social welfare than GDP

The GPI model is not intended to replace GDP or GSP, but to give decision makers a more holistic view and gather more complete information. The GPI model uses a diverse set of indicators to represent economic, environmental, and social factors of wellbeing. Although variations exist, the standard GPI model is based on a set of twenty-six indicators (see Figure 1 below depicting the GPI model for Maryland). These indicators derive from previous studies and avoid double counting of impacts.

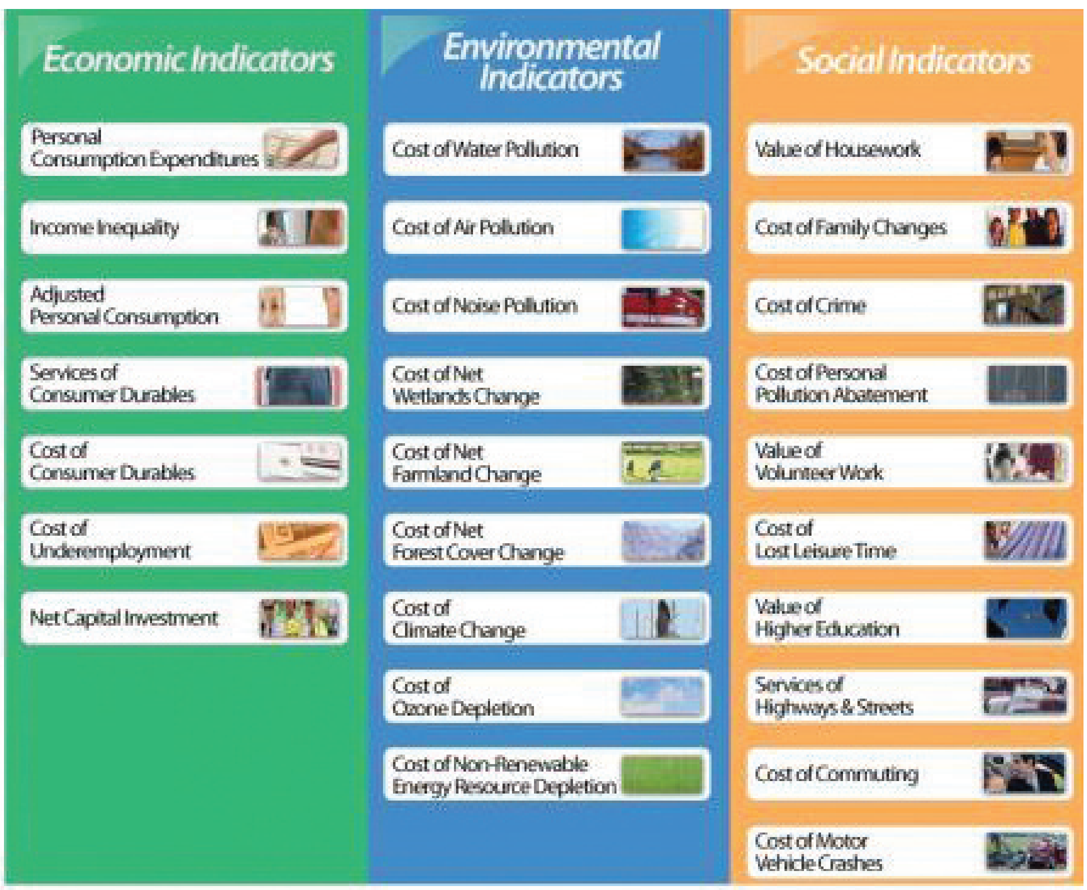
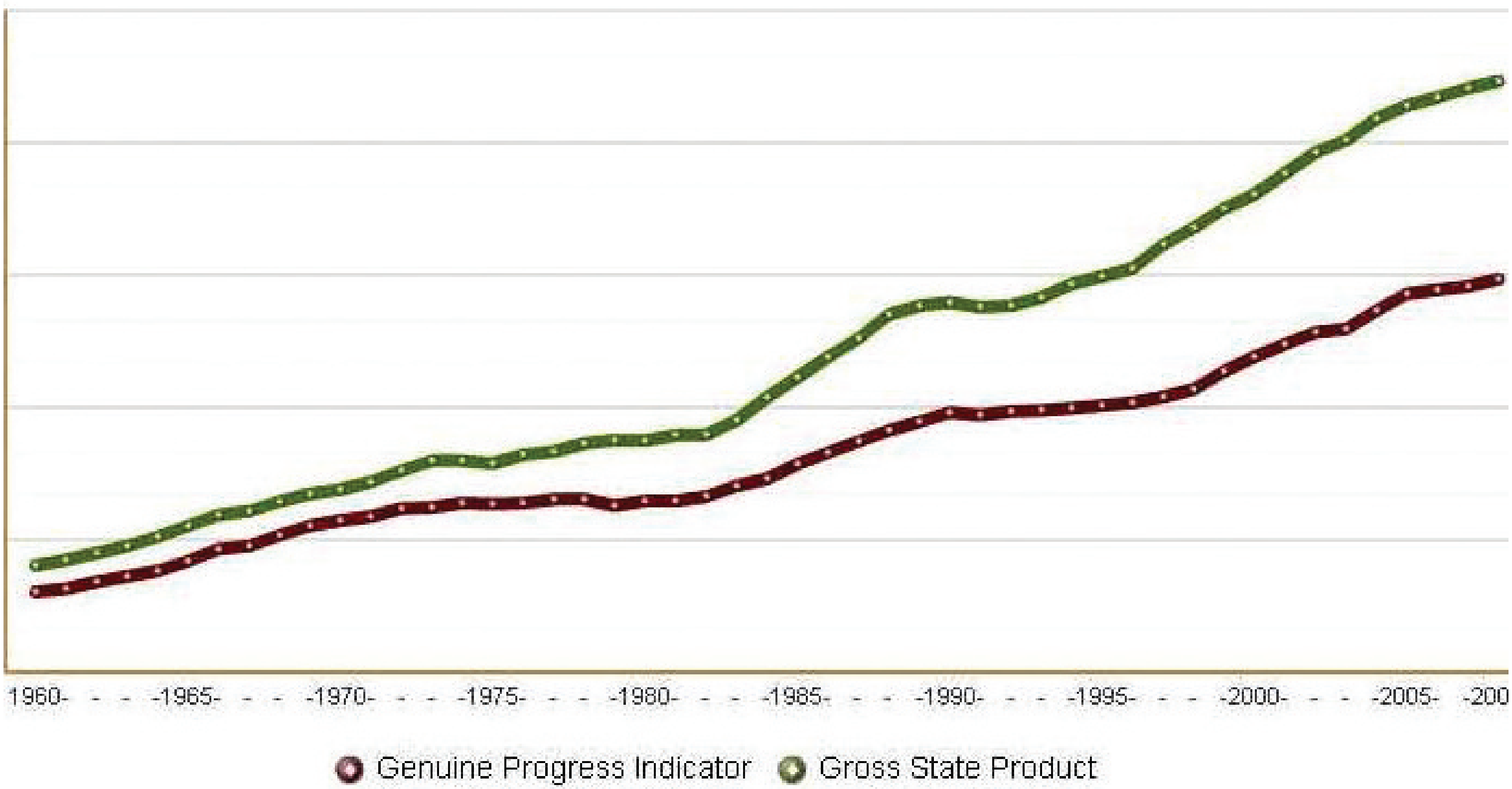


Figure 1. Maryland's 26 GPI Indicators (Maryland State Government, 2010); also available at http://www.green.maryland.gov/mdgpi/indicators.asp

(GPI) Introduction

Whereas GDP measures economic growth in the production sectors of the economy, GPI measures the byproducts resulting from broad economic activity. GDP and GPI have the same economic starting point, but GPI is further adjusted to subtract incidental costs or add unrecognized benefits to society that are not traditionally captured. When the result of the GPI calculation is compared with GDP, a divergence between the two measures occurs, as illustrated in Figure 2 for the case of Maryland for the years 1980 to 2010 (Maryland State Government, 2010).

Figure 2. Maryland's GPI vs. GDP 1980-2010 (Maryland State Government, 2010);
also available at http://www.green.maryland.gov/mdgpi/mdgpioverview.asp)



The point at which divergence begins is the threshold point. The deviation between the two measures raises the question of whether economic growth in the traditional sense has actually led to genuine social, economic, and environmental progress beyond the threshold point.

GPI is an established methodology

GPI studies exist at both the national and sub-national levels, across ten countries, including the United States. In the US, Costanza, et al. (2004) pioneered the prospect of GPI at multiple scales in their application to the state of Vermont. Other researchers using GPI in the US are listed below.

The most current GPI applications in the US include the states of Maryland (Maryland, 2010) and Utah (Berik & Gaddis, 2011). Further work in Vermont is currently in progress after the Vermont State legislature was the first US state to pass legislation in May 2012 establishing GPI as a budgetary and decision making tool (Demos, 2012).

Region	Study	Scale
United States	Talberth et al. (2007)	National
California	Bay Area Genuine Progress Indicator (2006)	8 CA counties; City of San Francisco
Maryland	Maryland Genuine Progress Indicator (2010)	State
Maryland	Posner (2010)	State; Baltimore County; Baltimore City
Minnesota	Minnesota Planning Agency (2000)	State
Ohio	Bagstad & Shammin (2009)	State; 17 OH counties; Cities of Akron and Cleveland
Utah	Berik & Gaddis (2011)	State
Vermont	Costanza et al. (2004)	State; Chittenden County; City of Burlington
Vermont	Bagstad & Ceroni (2007)	State; 7 VT counties

Table 1: Previous studies of the Genuine Progress Indicator (GPI) within the US, both national and sub-national scales (adapted from Posner & Costanza (2011)

Making the case for GPI

1. GPI relies on readily available data from existing sources

One of the strengths of GPI is that it relies on existing and publicly available data across various institutions. In cases in which data are not readily available at the local level, the model uses proxy data from national sources or extrapolates data from existing trends. The goal of the model is to encourage better-informed decision making with the resources that are available. However, given the wide breadth of the twenty-six indicators, the data are gathered from a range of disparate sources and may vary in completeness and precision. Weaknesses and the efforts to reconcile the data are documented accordingly and opportunities to refine the data collection efforts in the future are noted.

2. GPI is measured in dollars

Once data are collected across indicators for each year, the model aggregates the results into a single number with dollar units. Economic indicators are already captured in dollar terms, but the model must assign monetary units to environmental and social indicators to make aggregation possible. Depending on the nature of the indicator, its value will either add to or detract from GPI. An acre of wetlands, for example, is assigned an estimated dollar value that represents what that acre contributes to society in terms of biodiversity, flood control, or other ecosystem services. If that acre is lost or destroyed, the associated value is deducted from GPI.

Putting a dollar value on non-market goods and services, such as those provided by a wetland, is inherently difficult, yet is critical to establishing relative worth among resources managed by society. GPI relies upon valuation studies that investigate the direct and indirect use values, as well as non-use or inherent value of non-market goods. The model uses the best possible estimates from peer-reviewed and nationally accepted valuation studies (Maryland State Government, 2010).

Reporting GPI as a single number in dollar terms makes communication with the public, comparison across applications of GPI, and commensurability with other metrics much easier. Furthermore, that single number can be disaggregated to easily track the overall contribution and status of each individual component. For example, the overall GPI value provides guidance at the macro level of policy making, while the subset of environmental indicators can inform policy making across environmental issues. At the individual indicator level, for example the cost of water pollution, the dollar value can be broken down further to aid decision making about surface, ground, or coastal waters.

3. GPI tells a more complete story

In the end, the model provides not a precise number, but rather a coarse estimate that is powerful enough to illustrate relative magnitudes among indicators as well as general trends across time. Results for the cost of non-renewable resource depletion in a state heavily dependent on fossil fuels, for example, may show a major deduction from GPI relative to other environmental indicators. The results may also illustrate a downward trend over time as renewable energy becomes a larger proportion of the fuel mix.

4. GPI provides an innovative framework for policy makers

The GPI framework calls for a process-oriented approach while incorporating economic, environmental, and social factors into the policy-making process. In many respects, the process is just as important as the resulting product. In particular, policy makers can use the GPI framework to:

- Inventory and account for existing data across agencies;
- Provide a central repository for data across agencies;
- Facilitate collaboration among data owners;
- Envision future data collection efforts;
- Communicate with the public and other stakeholders; and
- Supplement other policy evaluation or budgeting tools.

A role for GPI in Hawai‘i (GPI-HI)

Each new application of GPI contributes to the standardization of the model and provides for greater comparability across studies, but at the same time generates benefits for the associated policy makers. Hawai‘i offers a unique and remarkable context in which to demonstrate the policy relevance and benefits of GPI. So to further explore this possibility, in August 2012 we formed a working group consisting of members from Hawai‘i Pacific University, College of Natural and Computational Sciences (HPU CNCS) and University of Hawai‘i Mānoa, Department of Natural Resources and Environmental Management (UHM NREM). Representatives from the State Environmental Council and the Office of Environmental Quality Control (OEQC) provided valuable input. Furthermore, the members of the Environmental Council generously offered its 2012 Annual Report as a forum for the wider dissemination of the results of our efforts.

GPI-HI approach

The HPU-UHM team's approach to developing the baseline GPI-HI included the following steps:

- *Review and evaluate previous GPI applications.* We used Maryland GPI as the primary model for the baseline study for Hawai‘i. Maryland is the first state government-led GPI initiative and the most comprehensive application to date.

- *Focus only on the environmental indicators for the baseline GPI-HI.* Of the twenty-six indicators, we focused initially on nine environmental indicators plus one indicator (personal pollution abatement) normally grouped with social indicators. Typically, environmental indicators account for a large portion of the deductions from GPI, e.g., approximately 30% of the divergence from GSP in Utah was attributed to impacts within the environmental indicators of the GPI model (Berik and Gaddis, 2010).

- *Inventory readily available data and identify ongoing collection efforts.* Current environmental data collection and reporting efforts span many agencies at the city/county, state and federal levels. We used locally generated data when available, and data from other states or the federal level as a proxy when necessary.

- *Gather existing valuation studies.* While biophysical data indicates changes in environmental conditions, valuation studies assign dollar figures to the loss or gain resulting from those changes. We surveyed the literature for relevant valuation studies, particularly those related to Hawai‘i.

- *Build a data repository.* GPI's structure helps to collect and store data in an orderly fashion within a centralized location. We used a series of Excel worksheets originally developed by the Maryland GPI team as our platform.

#	GPI-HI Baseline Indicator	GPI-MD Indicator
1	Cost of water pollution	#8
2	Cost of air pollution	#9
3	Cost of noise pollution	#10
4	Cost of net wetland change	#11
5	Cost of net forest change	#12
6	Cost of net farmland change	#13
7	Cost of climate change	#14
8	Cost of ozone depletion	#15
9	Cost of non-renewable resource depletion	#16
10	Cost of personal pollution abatement	#20
11	Cost of submerged coastal systems loss	N/A

Table 2. Environmental indicators included in the Hawai'i GPI exercise

- *Refine the model to better reflect local conditions.* We proposed adding a new indicator to capture the submerged coastal systems, given their economic, cultural, and environmental significance in Hawai'i.

- *Identify data trends and data gaps.* Once the spreadsheet was updated with Hawai'i data, we used Excel to generate the trends across indicators. This exercise was useful in determining data gaps, particularly those that ideally should be filled with locally generated information.

- *Provide recommendations for further actions and next steps.* Based on the outcome of the baseline study, we recommended next steps leading to a more robust model and ultimately better-informed decision making.

The findings from our baseline survey and the summaries of our methods are included here, in the Environmental Council's 2012 Annual Report. The final section of our report highlights the overall losses calculated as part of the GPI-HI baseline. It also includes our recommendations for further actions and next steps. We hope that this report will provide useful information to spur further discussions among policy makers and the public alike about the continued role of GPI in Hawai'i.

Pāʻū o Hiʻiaka, Kahoʻolawe –
Forest & Kim Starr ©

Introduction to issue

The State of Hawai'i contains almost 400 perennial streams, which support over 150 native aquatic species, including many endemic to Hawai'i. These streams also hold a cultural value as they are fundamental to traditional Hawaiian society. Approximately 30% of average annual rainfall in Hawai'i ends up as streamflow (DLNR, 2011), some of which feeds into fishponds, and much of which carries suspended minerals and nutrients to the ocean.

Clean water in the form of streams, aquifers, bays, estuaries, and ocean provide ecological services in the form of clean drinking water, healthy fisheries, recreation, aesthetics, increased property values, and healthy aquatic life. Clean water is ultimately the foundation for human life on these islands. As water becomes polluted through excess nutrients, sediments, heavy metals, or toxins, the costs that result are numerous. Examples include increased costs of treating drinking water, reduced tourism, loss of recreation, costs associated with the decline of fisheries, reduced property values, and the loss of aquatic life and habitats.

The upland forested watersheds of Hawai'i are immense reservoirs of biological diversity. They are responsible for recharging critical underground aquifers, and supply billions of gallons of surface water to agricultural, residential, and commercial sectors each year (Gutrich et al., 2005). However, the degradation and reduction of the Hawaiian rain forest have significantly impacted the watersheds. Hawai'i's forested watersheds are under great pressure from an increasing demand for water and further environmental degradation due to feral and invasive alien species. Management of the forested watersheds is crucial to protecting Hawai'i's clean water supply.

General trends

The quality of surface water extends to the quality of our drinking water, the demand for which is perpetually increasing. Municipal water resources and distribution systems for each island are largely the responsibility of the departments of water at the county level. In general, each purveyor, with oversight by the Hawai'i Department of Health, ensures the potable water supply is in compliance with maximum contaminant levels (MCLs) as mandated by the US Environmental Protection Agency (EPA). As of 2010, 99.9% of people in Hawai'i that were served with municipal drinking water received water that was in compliance with MCLs (Data.Hawaii.gov, 2012).

The State Water Code, Chapter 174C, Hawai'i Revised Statutes, established the Hawai'i Water Plan as a guide for implementing policy to address water supply and conservation. Initially approved in 1990, the Hawai'i Water Plan is run by the Department of Land and Natural Resources, Commission on Water Resource Management. The Hawai'i Water Plan consists of five components:

> *1) a Water Resource Protection Plan which is prepared by the Commission on Water Resource Management, 2) a Water Quality Plan which is prepared by the Department of Health, 3) a State Water Projects Plan which is prepared by the Engineering Division of the Department of Land and Natural Resources, 4) an Agricultural Water Use and Development Plan which is prepared by the Department of Agriculture, and 5) Water Use and Development Plans prepared by each separate county (Hawai'i Water Plan, 1997).*

The Hawai'i Department of Health's 2008/2010 Integrated Report contains a total of 204 marine segments and 91 stream segments that fail to meet regulated water quality standards, deeming the water body impaired (DOH, 2012a). The term "impaired" is used by the EPA to describe waterbodies (i.e., stream reaches, lakes, waterbody segments) not achieving federal water quality standards despite local efforts to reduce pollution. Impairments may be caused by exceeding total maximum daily loads (TMDLs); both bacteriological and chemical data are monitored for a water body. According to data collected by the Clean Water Branch (CWB) of the Department of Health (DOH, 2010; DOH, 2012a), the number of impaired streams in the state is on the rise. As of 2010, 24.2% of the perennial streams were deemed impaired. The quality of each stream is vital to the health of the watershed. Table 3 below depicts the decrease in water quality in streams tested by CWB and reported to EPA.

#	Island	Number of Perennial Streams Assessed	Number of Impaired Streams Reported in 2002	Number of Impaired Streams Reported in 2004	Number of Impaired Streams Reported in 2006	Number of Impaired Streams Reported in 2008/2010	Percentage of Impaired Streams by Island in 2010
1	Hawai‘i	132	12	15	16	17	12.8%
2	Kaua‘i	61	8	11	20	16	26.2%
4	Maui	90	9	10	11	11	12.2%
5	Moloka‘i	36	0	0	1	1	2.8%
6	O‘ahu	57	30	34	45	46	80.7%
	TOTAL	**376**	**59**	**70**	**93**	**91**	**24.2%**

Table 3. Number of impaired perennial streams by island (2002, 2004, 2006, 2008/2010) (DOH, 2010; DOH, 2012a)

Contaminants in Hawai‘i's water systems are also a concern for the state. The 2008/2010 Hawai‘i Integrated Report listed several locations identified and posted as areas where fish and shellfish should not be consumed. Contamination of fish and shellfish include organochlorine pesticides and/or PCBs and lead. These areas include: Pearl Harbor, Ala Wai Canal, and urban streams on Honolulu (DOH, 2012a).

As an island chain, the status of our coastal waters is also important, and the number of impaired coastal waters is also on the rise. Table 4 below depicts data provided by the Department of Health, Clean Water Branch. DOH is responsible for submitting data to the US EPA under the Clean Water Act. Nevertheless, there is a lack of agreement regarding the number of coastal waters for each island. Furthermore, the water quality reporting was delayed for 2010, and new data were not incorporated. (There is no report currently available for 2011 or 2012.) However, from the data that are available, we could discern that the number of impaired coastal waters is generally on the rise.

	Island	Number of Coastal Waters Assessed (2006)	Number of Impaired Coastal Waters (2006)	Percentage of Impaired Coastal Waters by Island (2006)	Number of Coastal Waters Assessed (2008/2010)	Number of Impaired Coastal Waters (2008/2010)	Percentage of Impaired Coastal Waters by Island (2008/2010)
1	Hawai‘i	89	31	34.8%	83	33	39.8%
2	Kaua‘i	81	26	32.1%	64	23	35.9%
3	Lāna‘i	17	6	35%	12	8	66.7%
4	Maui	122	72	59%	84	72	85.7%
5	Moloka‘i	37	3	8.1%	32	3	9.4%
6	O‘ahu	176	71	40%	114	65	57%
	TOTAL	**522**	**209**	40%	**389**	**204**	52.4%

Table 4. Number of impaired coastal waters by island (2006, 2008, 2010) (DOH 2010; DOH, 2012a)

GPI approach

The pollution of water through excess nutrients, sediments, heavy metals, or toxins results in a variety of costs. Where Gross State Product (GSP) would include the spending required by these environmental and social losses as a positive economic gain, the GPI adjusts the GSP to count them as negative values. The cost of water pollution can be evaluated in various ways, however each must begin with an assessment of water quality. As each state is required to submit an annual list to the EPA identifying waters that are not achieving water quality standards, the GPI approach merely extends this requirement of the Clean Water Act by adding a monetary value (Berik and Gaddis, 2011; Posner, 2010).

The value of clean water stems from beneficial uses, which generally include drinking water, recreation, aquatic uses, and agriculture. Maryland developed a new methodology for assigning a monetary value for water pollution, believing that previous state-level studies and values from national GPI studies underestimated the cost. Following Costanza, et al. (2004) and Maryland Department of Natural Resources reports, Maryland determined the value of clean water to be $130 per person per year (in 2000 USD), or $676.52 million per year for the state of Maryland. The annual cost of water pollution was calculated as the value of clean water multiplied by the percentage of waterways that were degraded. The national GPI calculations have included erosion damages as part of their water calculation indicator. While erosion is considered a significant problem, those damages were found difficult to determine at a state level, and therefore not included in the Maryland study.

GPI-HI approach

As mandated by the EPA, Hawai‘i records impaired streams and coastal waters for the state. Currently, these data are available as "number" of water bodies, which we can convert to a percentage of total streams or coastal waters for the GPI. However, for the future it may be a more accurate replication of the Maryland study to include distance (i.e., miles) of the waterway or water body when calculating the percent of impairment. Future efforts will also evaluate the efficacy of using a metric of area rather than distance to measure the relative quality.

For GPI-HI, we followed Maryland's example by using a value of $130 per capita (in 2000 USD) and the following equation adjusted for Hawai‘i to calculate water pollution costs for each year of data available:

Cost of water pollution = (State population) x ($130 per capita) x (% degraded streams)

For the year 2010, the cost of water pollution for the state of Hawai‘i is valued at $43 million (USD 2000). The average annual cost in the period for which data was available (from 2000 to 2010) is estimated at $34 million (USD 2000).

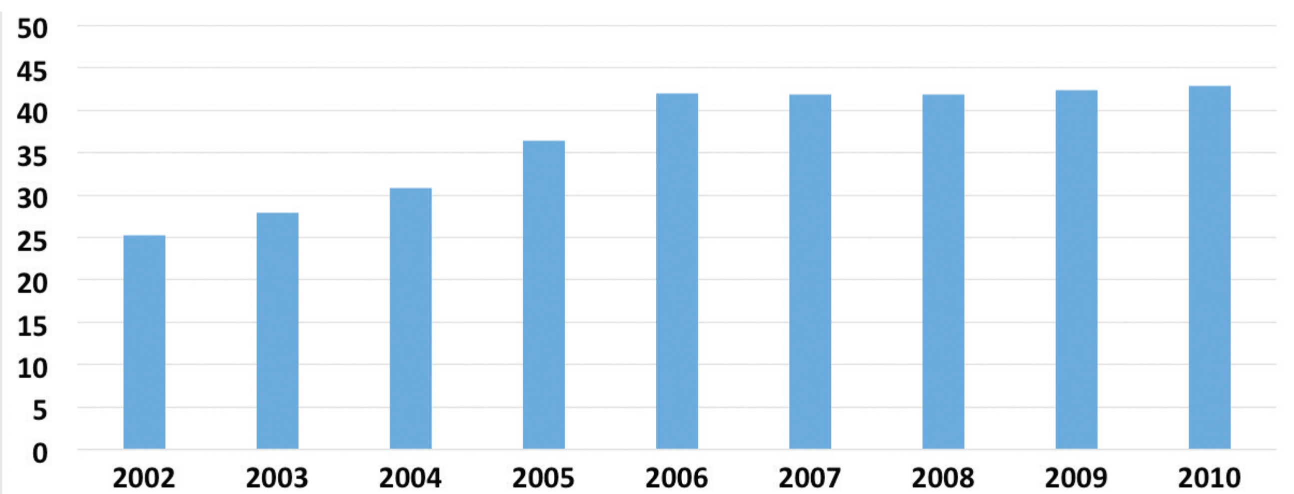


Figure 3. Cost of water pollution from impaired streams in Hawai‘i (2002 – 2010) (millions 2000 USD)

Water Pollution (Cont.)

For the baseline GPI-HI, we decided not to use the percentage figures for degraded coastal waters. Instead, in the future we hope to capture the value of coastal waters in conjunction with a new indicator for coral reef ecosystems, being careful to avoid double counting of value between this indicator and the new indicator.

As Hawai'i is a top tourist destination with rich tradition and culture, more current local valuation studies need to be done to ascertain appropriate values for clean water. A higher estimate of the value of local water would incorporate Hawai'i's unique tropical environment and beautiful beaches. Similar to the paucity of valuation studies on water, Kaiser et al (2002) notes that the value of beaches in Hawai'i is also difficult to estimate, and that any estimate may not reflect their true value. Several studies of the values of beaches exist as conducted for example by Moncur in 1972, the Army Corps of Engineers in 1991, and Bell and Leeworthy in 1991 (as cited in Kaiser et al., 2002), but a more comprehensive assessment is required to determine the number of beach days spent on a per visitor basis. It would also be useful to know which beaches were visited and how many times. Hanauma Bay, for example, is a location where the demand can be assessed (Kaiser et al., 2002).

Honu – Anita Wintner ©

A Few Facts about the Hawaiian Monk Seal

Right: Hawaiian Monk Seal – Kathleen Ho ©

Below: Mom & Pup – Mark Sullivan NMFS, NOAA

The Hawaiian monk seal is in danger of going extinct.

- *The monk seal is known in Hawaiian as 'īlioholoikauaua, "dog running in the rough sea," or nā mea hulu, "the furry ones."*
- *Hawaiian monk seals are endemic to the Hawaiian Islands. This means that they occur here naturally without human introductions, and they are found nowhere else on earth.*
- *Hawaiian monk seals are one of the most endangered marine mammals in the world with an overall population decline of 4% a year.*
- *The coral reefs found around the Hawaiian Islands provide the monk seal with its food supply: lobster, eels, small octopus, and reef fishes.*
- *The seal's continued existence is threatened by low pup mortality, sharks, human interactions such as accidental hookings, entanglement with marine debris and derelict fishing gear, diseases, and attacks by aggressive male seals,*
- *Mothers stay with their pups from birth to about 5 or 6 weeks, never leaving them unprotected to go feed.*
- *Monk seals haul out on our beaches to sleep, sometimes for days at a time, and to give birth and nurse their newborn pups.*
- *Monk seals do not migrate seasonally, but some seals have been tracked traveling hundreds of miles in the open ocean. I ndividual seals often frequent the same beaches, but do not defend regular territories.*
- *Hawaiian monk seal recovery efforts are overseen by the National Marine Fisheries Service, in cooperation with other government and private organizations and universities.*

Introduction to issue

Clean ambient air is essential to the health, productivity, and quality of life of the population, and state and federal agencies play a crucial role in protecting citizens from harm. The harmful impacts of air pollution vary depending upon the pollutant itself and the exposure to it. Critical pollutants include, among others, ground level ozone (a key component of smog), sulfur dioxide, particulate matter (both coarse and fine), and carbon monoxide. Generally, exposure to elevated levels of these pollutants can be linked to irritation of the respiratory system, reduction in lung function, increased heart disease, or aggravation of asthma or other chronic lung diseases. While it is important to consider health effects on the general population, sensitive subpopulations such as children, asthmatics, and the elderly are even more susceptible to air pollution.

Air pollution impacts not only human health, but also the health of ecosystems and the services they provide. Pollutants in ambient air can lead to environmental impacts such as degraded visibility or damage to buildings, animals, crops, and vegetation. These secondary impacts make the role of state and federal agencies even more critical.

The Clean Air Act (CAA) requires states to design a network of stations to routinely monitor and detect pollutants dispersed or suspended in the air. Agencies are then responsible for comparing those detected levels to acceptable standards set at the national and/or state regulatory level. These National Ambient Air Quality Standards (NAAQS) were designed to limit the exposure of the public to six so-called criteria air pollutants: particulate matter (both PM_{10} and $PM_{2.5}$); ground level ozone (O_3); sulfur dioxide (SO_2); nitrogen oxides (NOx); carbon monoxide (CO); and lead. The standards are designed primarily to protect public health, including sensitive subpopulations. If the level of a pollutant exceeds that specified in the NAAQS, then the state is said to be in nonattainment for that pollutant for that particular time period.

General trends

In Hawai‘i, the Department of Health (DOH), Clean Air Branch is responsible for monitoring the ambient air for certain pollutants to ensure that air quality standards set by EPA and the state are met. These pollutants include airborne particulates (PM_{10} and $PM_{2.5}$); sulfur dioxide (SO_2); nitrogen dioxide (NO2), ozone (O_3), lead (Pb), carbon monoxide (CO), and hydrogen sulfide (H_2S). The DOH maintains twelve (formerly thirteen) air monitoring stations across four islands (O‘ahu, Maui, Hawai‘i, and Kaua‘i) to track how ambient conditions are impacted by both anthropogenic and natural sources of air pollution. Six special purpose monitoring stations are situated on the Big Island of Hawai‘i to check impacts on air quality from Kīlauea Volcano as well as geothermal energy production. O‘ahu has the largest population and highest levels of industrial, commercial and transportation activities that are tracked by four (previously five) urban monitoring stations on that island. Maui's single station monitors sugar cane burning, while Kaua‘i's new and only station was established especially to monitor potential impacts from cruise ships. Of the total monitoring stations, the majority screen for $PM_{2.5}$ and/or SO_2; no single monitoring station measures all criteria air pollutants (DOH, 2012b).

Hawai‘i is widely recognized for its high quality of ambient air, even while trends in many other states continue to show problems with $PM_{2.5}$ and ground-level ozone, particularly when accompanied by increases in urbanization. According to the American Lung Association's (2012) annual State of the Air, Honolulu ranks first in cleanest metropolitan areas for ground level ozone, and eighth overall when including short- and long-term measures of particulates. Honolulu consistently ranks high on EPA's Air Quality Index (AQI) and Air Pollution Index (API) as reported on the AIRNow website, a consortium of federal, state and local agencies aimed to provide national air quality information to the public (AIRNow.gov, n.d.). With the exception of stations in communities in proximity to Kīlauea, monitoring of ambient air conditions by DOH consistently show air quality conditions that are well below the standards prescribed by NAAQS (DOH, 2010; DOH, 2012b; DOH, 2012c).

Yet Hawaiʻi is also unique from other states due to the recent and continued natural and uncontrollable emissions from Kīlauea Volcano on the Big Island of Hawaiʻi. Volcanic activity increased considerably in March 2008 due to a new opening of the Halemaʻumaʻu Vent, leading to increased sulfur dioxide (SO_2) and fine particulate matter ($PM_{2.5}$) emissions on the Big Island. The resulting vog (i.e., volcanic smog) occurs when volcanic gases and particles combine with air and sunlight to produce atmospheric haze. Although naturally occurring, vog impacts human health just as the related anthropogenic pollutants do. Readings from monitoring stations in proximity of the volcanic emissions frequently exceed the NAAQS levels for SO_2 and occasionally exceed the NAAQS for $PM_{2.5}$ (DOH, 2012b).

When subtracting out the number of exceedances due to volcanic activity from the overall results of monitoring for the state, Hawaiʻi was in attainment of all NAAQS for 2011. Given that volcanic activity is an act of nature, if it is considered an exceptional event by EPA, then related exceedances are excluded from the determination of attainment or nonattainment. State officials (in conjunction with other federal agencies) continue to assess the ongoing vog and sulfur dioxide issues and provide up to date information and guidance to citizens via real-time, 15-minute SO_2 levels and corresponding advisories (online at www.hiso2index.info).

GPI approach

Within the GPI framework, the air pollution indicator relies on monitoring of ambient air to identify harmful levels of contaminants in the air, either gaseous or particulate matter. Air pollution is an externality, or byproduct, that is not captured by GDP/GSP, regardless of the cost it places on society. Indeed, certain costs of air pollution can even be misconstrued to increase GDP or GSP.

Past GPI studies have taken a variety of approaches for this indicator. In Utah, Berik and Gaddis (2011) used county and state level emissions of specific air pollutants multiplied by the per ton cost of emissions taken from a study by Mueller and Mendelsohn (2009) to estimate total damages due to air pollution. However, other GPI models such as Anielski and Rowe (1999) and Costanza et al. (2004) incorporated cost figures for damage to forests, farmland, and urban environments. This approach builds upon an earlier Freeman (1982) cost-benefit analysis of the national cost of air pollution in 1970 disaggregated across those three sectors.

Maryland GPI modified these earlier studies to scale down to sub-national level by using the ratio of state to national figures for forest, farmland, and population and designating that amount as the 1970 baseline year. Additionally, in the case of Maryland, researchers created an air quality index related to ambient ground-level ozone values to track changes in pollution damage, since high levels of that pollutant remain an ongoing problem for the state. Maryland looks at the trends in ozone days and incorporates the number of days over the 8-hour limit for ozone per year relative to the previous year to scale the costs accordingly. The general equation used by the Maryland study is as follows:

Cost of air pollution = (cost of air pollution in 1970 scaled to Maryland levels) + (costs of air pollution in other years based on ground level ozone levels and national air pollution trends)

Whereas the *cost of air pollution in 1970 = ($14.74 x MD acres of farmland/US acres of farmland) + ($5.48 x MD acres of forest/US acres of forest) + ($88.39 x MD population/US population).*

The monetary figures in the above equation are in 2000 USD.

GPI-HI approach

On the surface, the costs of air pollution for the State of Hawaiʻi appear to be minimal relative to other states. For example, the equation from Maryland incorporates ground-level ozone exceedances, a problem not applicable to Hawaiʻi. Moreover, and fortunately for our citizens, the prevailing trade winds tend to carry air pollutants away. In addition, unlike the contiguous states, our geographical location means we are not subjected as much to interstate transboundary air pollution.

So for the baseline GPI-HI, we contemplated using only that portion of the above equation that is based on Freeman's (1982) earlier work. This would be achieved by multiplying the national estimates of air pollution damages to agriculture, forests, and urban environments by the corresponding Hawai'i figures for acres of farmland, acres of forest, and state population. After analyzing those studies further we identified several weaknesses in this approach (e.g., not including health costs within the calculation) and its implementation (e.g., errors in calculations) and were dissuaded from using it. Furthermore, since the typical impacts of air pollution on farmland, forests, and the population may not apply to Hawai'i due to its unique geographical location and wind patterns, this calculation is not necessarily a good proxy for the GPI-HI baseline. Therefore, we have chosen not to include air pollution costs in the baseline calculation for GPI-HI.

Nevertheless, the costs of air pollution are not negligible in Hawai'i and need to be explored further. Regardless of its applicability, the above calculation can highlight various unknowns that deserve examination for future GPI-HI efforts. For example, the number of sites monitoring ambient air quality in the state is limited. As urbanization increases, its associated drawbacks, such as increased traffic congestion and air pollution, might not be adequately accounted for with current monitoring efforts. Moreover, even though the prevailing trade winds carry air pollutants away, those pollutants generated from our activities here will eventually be felt somewhere else. Yet the ultimate impacts will not be accounted for because those results will be elsewhere and/or will remain unknown.

For future refinement of the costs of air pollution for GPI we will consider the Mueller and Mendelsohn (2009) study; currently their model estimates air pollution damages down to the county level, however it only applies to the contiguous United States. Furthermore, the role of GPI is to tell a story and show trends in impacts on social welfare. Just like Maryland chose to use the number of exceedances of 8-hour ozone levels to signify a significant problem in that state, GPI offers the flexibility to reflect local conditions that bring about associated air pollution costs. Excluding the naturally caused and uncontrollable elevated levels of a pollutant is not telling the full story. To refine GPI-HI, we will further examine the costs from the health impacts of vog associated with SO_2 and PM emissions, noting how these costs vary across the counties. These costs are borne by society, but are not adequately captured; in many cases the related incidents actually increase GSP. GPI can provide the framework to recognize those costs.

cost of Noise Pollution

Introduction to issue

Loud, intrusive noises are so pervasive in our surroundings, particularly in urban areas, that they are considered a form of pollution. Noise pollution is regulated under the Clean Air Act (CAA) and the Noise Control Act of 1972, although primary responsibility for addressing noise issues takes place at the state and local government levels. According to EPA, noise pollution has adverse effects on the lives of millions of citizens, and can impact both enjoyment and health. Direct links between noise and human health can be found in a range of impacts including stress-related illnesses due to sleep disruption, lost productivity, or hearing loss. Research shows that exposure to high levels of noise at a constant rate can cause particularly adverse health effects (EPA, 2012c)

Trends in Hawai'i

In Hawai'i, the community noise program resides in the Hawai'i Department of Health (DOH), Indoor and Radiological Health Branch (IRH). Responsibilities include enforcement of maximum permissible sound levels for stationary noise sources and issuance of permits for agricultural, construction, and industrial activities (DOH, 2011).

GPI approach

Under the GPI approach, noise pollution is a cost to be subtracted from GSP because it disrupts the quality of life primarily for those residing in areas of increased urbanization. Past GPI studies worked with the 1972 estimate by the World Health Organization (WHO) that damage caused by noise pollution in the US was $4 billion (Congressional Quarterly, Inc. 1972 as cited by Talberth et al., 2007). The national GPI studies used this base figure and assumed that the national cost of noise pollution increased by 1% per year from 1973 onward (Anielski & Rowe, 1999; Constanza et al., 2004; Bagstad & Ceroni, 2007; Bagstad & Shammin, 2012). The Maryland sub-national study assumes that the cost of noise pollution is tied to the level of urbanization. Therefore, the national level damage estimates from the previous national GPI studies were scaled down to the state level by comparing Maryland's urban population with the national urban population. The equation is shown as:

Cost of noise pollution = National cost of noise pollution from WHO study x (state urban population/US urban population)

GPI-HI approach

To calculate the GPI-HI baseline for noise pollution we followed the example of Maryland and adapted it to include the urban population in Hawai'i. First, we found the general trends of urbanization as shown in the table below (DBEDT, 2012; US Census Bureau, 2011).

Then, we scaled down the national costs of noise pollution by the ratio of Hawai'i urban to national urban population. We made the final calculations based on the equation above.

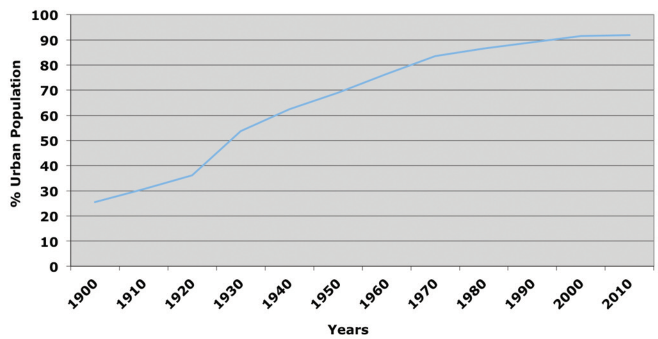


Figure 4. Growth of urban population in Hawai'i as percent of total population1900-2010 (DBEDT, 2012; US Census Bureau, 2011)

For the year 2010, the cost of noise pollution for the state of Hawai'i is valued at $104 million (USD 2000). The average annual cost in the period for which data was available (from 1960 to 2010) is estimated at $80 million (USD 2000).

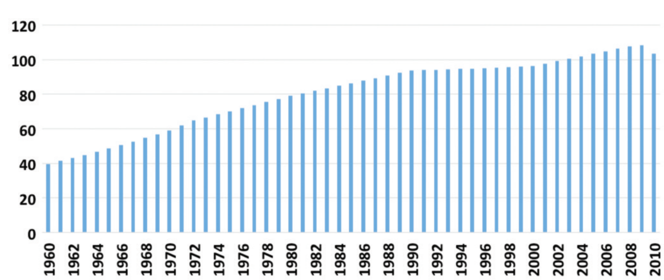


Figure 5 - Cost of noise pollution in Hawai'i 1960-2010 (millions 2000 USD)

All previous GPI studies acknowledged the need for better characterization of noise pollution for future GPI estimates. For future GPI-HI estimates we will continue to look for alternative measures of costs as used in the GPI literature generally or as found for the state of Hawai'i specifically.

Introduction to issue

Wetlands provide a host of valuable services in terms of water quality, flood control, biodiversity, cultural resources, recreation and pure aesthetic inspiration. Wetlands filter pollution, waste, and sedimentation from water, purifying it as the water travels through the wetland. Wetlands act as a shock absorber during periods of excessive rains or tidal fluctuations. Wetlands provide critical habitat and breeding grounds for many species of flora and fauna. Many of these species are threatened or endangered native species, and some are only found on the Hawaiian islands, such as the *ʻalae keʻokeʻo* (Hawaiian coot), *ʻalae ʻula* (common moorhen) and the *aeʻo* (black-necked stilt). Since Hawaiians first settled around the coastal and wetland areas, the wonders of the wetlands are thoroughly incorporated into Hawaiian history, cultural identity, and spirituality. Moreover, wetlands provide abundant recreational activities such as fishing, hunting, bird watching, as well as a place of intrinsic aesthetic beauty (Brander et al., 2006).

The wetlands of Hawaiʻi could fall into one of several categories whether based on the percentage of herbaceous vegetation, trees and shrubs, or water salinity levels. However, as is true with forest cover, it is not a simple case of classifying by the ecosystem type. There is an important distinction to be made between wetlands with healthy, native vegetation and those that are overrun with invasive exotic vegetation that displaces the rare and endangered native species while radically changing the quality and function of the wetlands. Mangroves are such an example. Mangroves are a common and valuable part of ecosystems elsewhere, but have infested large areas of estuarine wetlands in Hawaiʻi, crowding out native species and traditional land uses such as fish ponds that are important to Hawaiian culture.

Trends in Hawaiʻi

During the original settlement period in Hawaiʻi, the Polynesians had minimal impact on the wetlands through their traditional agricultural and fishing practices and the establishment of small communities around the perimeter of the wetlands. Nevertheless, later development has resulted in a great reduction of wetlands in terms of both acreage and quality. Over time, the impacts of population growth, pollution, development, sedimentation, and the introduction of countless exotic species began to accelerate, resulting in the current state of affairs.

At the state level, the Department of Land and Natural Resources (DLNR) and the Department of Health (DOH) share responsibility for the protection and restoration of Hawaiʻi's wetlands. DLNR has worked hard over the years to develop watershed management partnerships with many private and public entities including local organizations, cultural groups, schools, and community members.

Though generally the data for the state are sparse, the interagency database developed by the US Department of Interior and the USDA Forest Service called LANDFIRE shows an estimate of 12,596 acres of wetlands remaining in Hawaiʻi as of 2000. Fortunately, no significant losses in wetland coverage is indicated since that time (US DOI, 2012). Similar to the forestry sector, recent decades have seen a reversal in the trend as greater effort and capital is being spent on protection and management of the wetlands by the state and the aforementioned wetland management partnerships. Unfortunately, the raw data to support these observations are difficult to find for various reasons. First, it is not easy to disaggregate state designated "conservation lands" into forests, wetlands, and grasslands. Second, the data are dissimilar among the various sources and no singular source was adequate to develop a reliable time-series analysis.

Yet concerns exist over not only the quantity, but also the quality of the wetlands remaining. A more detailed GAP analysis in 2006 revealed that of the remaining acres of wetlands, only 2,652 acres were considered in a state of "effective conservation," i.e., both actively protected and adequately managed -- including the control of exotic/invasive species (Gon et al., 2006; Friday et al., 2011). At least half of all wild species in Hawaiʻi today are non-indigenous, highlighting the issue of alien species and the threats they represent to the island ecosystem. The vast majority of alien species that arrived in Hawaiʻi can be attributed to human activity, introduced intentionally or unintentionally. Alien species destroy native habitat, compromise ecological processes, and reduce the value of associated ecosystem services (Kaiser & Roumasset, 2002).

GPI approach

The goal of the GPI is to recognize the value on the non-market benefits of environmental goods and services. For this indicator, the GPI attempts to put a value on the wetland contribution to clean water, biodiversity, and recreation, as well as its cultural and aesthetic benefits, thereby attributing a monetary value for each acre restored or lost.

Net Wetlands Change

Previous GPI studies calculated the cost of net change in wetlands as total wetlands lost multiplied by the estimated wetland value per hectare; all calculations are based on the earlier work of Costanza et al. (2004). Maryland (2010) used a wetland value of $1973 (in 2000 USD) per acre per year beginning in 1950, increasing by 2% annually. Ohio used an estimate of $396 per acre per year for losses from settlement to 1940, $1973 per acre per year from 1940 to 1950, and then added 2% per year in subsequent years (Bagstad & Shammin, 2012). However, in some counties in Ohio where wetlands were particularly scarce due to population and urban sprawl, the GPI team decided to increase the value of wetlands by 3% per year, following Bagstad and Ceroni (2007). Utah chose to follow Dodds et al. (2008) by estimating wetland value as $22,453 per acre (in 2000 USD). Unlike other states, Utah chose to assess the positive value of wetlands in hand, i.e., the existing stock, rather than calculating the loss in wetlands over time (Berick & Gaddis, 2011). This strategy avoids the problem of selecting a baseline, such as pre-settlement, and estimating the history of wetland loss over time.

GPI-HI approach

To develop a baseline for GPI-HI, we looked for both wetlands inventory data and available related valuation studies. To get a sense of wetlands loss, we evaluated several sources of remote sensing data including LANDFIRE (US DOI, 2012), Gon et al. (2006), the Hawai‘i Statewide Assessment of Forest Conditions and Resource Strategy (DLNR, 2010), and NOAA C-CAP for the years 1992, 2000, 2001 and 2005 (NOAA, 2012b). Analysis of NOAA C-CAP data from 1992 suggests a wetlands inventory for that year of 14,229 acres. Due to the lack of data and inconsistencies among data sets, we could not get a clear picture of wetlands losses. Nevertheless, both the LANDFIRE data and the NOAA C-CAP data corroborate that in the year 2000, there were between 12,637 and 12,596 acres of wetlands remaining. Based on the higher of these two values, we calculated a net loss of wetlands as 1,592 acres between 1992 and 2000.

To date, there are no valuation studies of wetlands for Hawai‘i or other islands or similarly isolated sites. Considering Hawai‘i's biodiversity, vibrant and unique cultural heritage, heightened dependence on ecosystem services of wetlands, and remoteness, future GPI-HI efforts will refine the estimated wetlands value. For example, a more realistic estimate might be more in line with the Dodds et al. (2008) estimation of $22,453. However, to remain on the conservative side and be able to compare Hawai‘i to other GPI analyses, we utilized Maryland's model of scaled estimations, increasing 2% per year from the baseline of $1,973 per hectare in the year 1950. The value of wetlands for the years in which data are available for Hawai‘i ranges between $4,443 and $5,206 per hectare.

For the baseline GPI-HI, we used the following equation:

The cost of net wetland change = (# acres lost) x (estimated wetland value per acre)

For the year 2000, the cost of net wetland change for the state of Hawai‘i is valued at $1.04 million (USD 2000). The average annual cost in the period for which data was available (from 1993 to 2000) is estimated at $1.11 million (USD 2000).

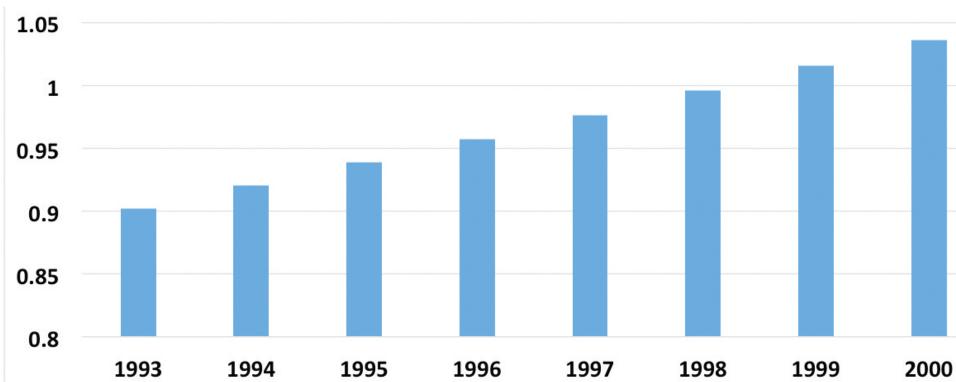


Figure 6. Cost of wetland change (1993-2000) (million 2000 USD)

In future efforts to refine the GPI in Hawai‘i, we will examine time-series remote sensing data. Other than NOXA C-CAP data, the state itself has little if any information in this regard. In order to really capture the value of wetlands in Hawai‘i, however, greatest recognition of how factors, such as exotic species invasion, lead to declines in the functionality and quality of the wetlands is needed. Currently, Hawai‘i-specific valuation estimates of various wetland ecosystems, particularly those with a high predominance of invasive species, are lacking. Therefore, future improvements in both assessment and valuation data are desired.

Introduction to issue

Situated at least 2500 miles away from the agricultural and food production centers of the continental United States, change in agricultural production capability is exceptionally important to Hawai‘i (Leung & Loke, 2008a). Anywhere from 85% to more than 90% of food consumed in Hawai‘i is imported (Leung & Loke, 2008a), resulting in significant transportation costs and associated carbon dioxide emissions while impacting the quality and quantity of the available food products. Once consisting of sweet potatoes, taro, and yams, agriculture in Hawai‘i shifted to cash crops such as sugar and pineapples as plantations came to dominate the industry (Page et al, 2007). Due to competition from developing countries, changing market preferences, and the price of land and water, cash crop production declined in Hawai‘i, and is being slowly replaced by more diversified agricultural production, expanding to include other vegetables, fruits, flowers, and biofuels (Burnett & Wada, 2012). This diversification is not only filling the void left by the collapse of the cash crops and plantations, it is also beginning to reduce Hawai‘i’s reliance on imported produce, confirming progress towards achieving our economic goal under the Hawai‘i 2050 Sustainability Plan – “increase production and consumption of local foods and products” (Hawai‘i 2050 Sustainability Task Force, 2008).

A loss of area under agriculture results in costs to society in several ways. A loss in farmland restricts the ability to grow food locally, regardless of whether that produce is intended for local consumption (to offset the cost of importing food) or for sale outside of the state (thereby increasing Gross State Product [GSP]). Moreover, changes in farmland can compromise ecosystem services and diminish cultural significance, resulting in much more than just a loss in the amount of production that is captured by GSP.

General trends in Hawai‘i

Between 1959 and 1974, large plantations were abandoned and the area under agricultural production declined by 50% to 1.1 million acres. By 1974, the number of farms had dwindled to just 3,000 from over 6,200 in 1959. Though the acreage of farmland is still declining in Hawai‘i (Figure 7), losing an additional 4,500 acres since 2003 (see graph below), the last four decades have seen positive changes. The number of farmers has rebounded, particularly since 2004, climbing to almost 7,000 in 2007 (Burnett & Wada, 2012). Individual farm size is smaller, but data suggest that it is the production from the smaller farms that is flooding the local markets, while the largest farms are responsible for most of the exports to the mainland and international markets. Between 2004 and 2008, agricultural exports fell $28 million, from $599 million to $571 million, while local consumption increased $29 million over the same period (USDA, 2010). Since 2007, agricultural production has remained fairly stable.

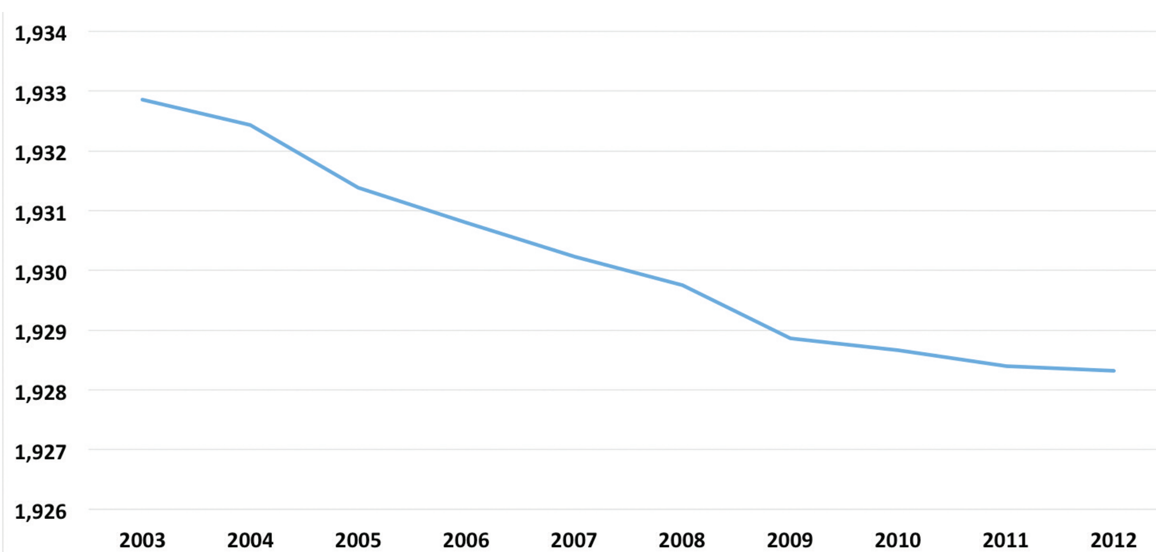


Figure 7. Recent trends in farmland area (2003-2012)
(DBEDT, 2012 Table 6.03 “Estimated acreage of land use districts 1964 to 2011”)

Net Farmland Change

Leung and Loke (2008a) cite studies suggesting 85% to more than 90% of food consumed in Hawai‘i is imported. If a portion of the spending on imported agricultural products switched to local products instead, a "rippling" effect could be expected in the local economy. The question is whether $6 million in additional tax revenue from a 10% replacement with local agricultural activity is enough to fund government initiatives to encourage such efforts. Leung and Loke (2008b) suggest that while sugar and pineapple production continue to decline in the state, diversification in agriculture allows the sector to remain a contributor to the state's economy. Said contribution may differ based on how agriculture is defined. Page et al (2007) attempt to identify why local food holds such a small market share (85% imported), barriers to increasing local food market share, areas where investment yields positive results for local agriculture, and actors who can make those investments.

GPI approach

Gross State Product (GSP) accounts for the values of agricultural production alone. Agricultural lands provide environmental services, such as water filtration. Agricultural lands are also a cultural asset, a source of pride in deep-rooted traditions, creating strong community bonds in addition to the intrinsic value of open land, a refuge from the urban centers. Therefore, the loss of agricultural lands and the agricultural way of life has broader impacts on social well-being, which is not captured by the changes in agricultural production alone or GSP.

The Maryland, Ohio, and Vermont GPI studies used USDA data to arrive at the total area under agriculture. Maryland stated that the National Agricultural Statistics Service (NASS) had the most complete and accurate time-series data. Likewise, the previous studies chose to value agricultural lands using the estimate from the Costanza et al. (2004) study, which fixed the value of an acre at $404. Maryland, however, increased the estimate to $1,131 based on the observation that Maryland's agricultural productivity per acre was 2.8 times higher than the national average (Maryland, 2010). In a different approach, Utah used the market value of preserving agricultural lands through conservation easements and arrived at values between $578 - $66,935 (in 2000 USD), depending on the county (Berik & Gaddis, 2011). The following equation illustrates the generic approach taken by the GPI studies:

The cost of net farmland change = (# acres lost) x (estimated farmland value per acre)

GPI-HI approach

In the case of Hawai‘i, the quality of historical land use data used by USDA and other national and state agencies varies between sources, but has been recently improved by remote sensing data. To determine the value of farmland in Hawai‘i, we looked at several data sources, including NOAA C-CAP remote sensing data for the years 1992, 2000, 2001, and 2005, the State of Hawai‘i Data Book (1964-2011), USDA-NASS (1990-2010), and USDA Census of Agriculture (1840-2007). Based on our discussions with remote sensing experts in Hawai‘i, we concluded that the State of Hawai‘i Databook provided the most consistent and applicable time-series data.

According to the US EPA (EPA, n.d.), the value of an average acre of US agricultural land in the year 2000 was "over $1000" while land planted in corn was valued at more than $3000 per acre. For the baseline GPI-HI, we chose to be conservative and use the Maryland-based $1131 per acre figure as starting point. This figure, along with the data from the Databook are incorporated into the following equation to calculate a baseline.

The cost of net farmland change = (# acres lost) x (estimated farmland value per acre)

For the baseline GPI-HI over the time frame for which data were available, we estimated an average annual cost of $185 million dollars (in 2000 USD). For the time period of 1965 to 2010, the estimated cost of farmland loss is $8.5 billion (in 2000 USD). Trends are shown in Figure 8.

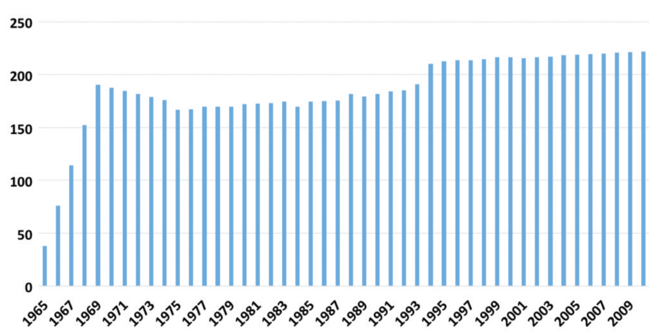


Figure 8. Cost of net farmland change (1960-2010) (million 2000 USD)


Kaua'i Lo'i Kalo & Ae'o – Jack Jeffrey ©


Fresh O'ahu Produce – Kukui Maunakea-Forth ©


Organic Moloka'i Honey – Malia Akutagawa ©

For future refinements of GPI for Hawai'i, we will gather the data required to formulate farmland value per acre from either the State of Hawai'i Data Book, available on a yearly basis, or USDA Census of Agriculture data, generally available in five year increments. The estimated farmland value per acre will also be refined, recognizing in particular the high land values, transportation costs of importing produce, and the unique significance of agriculture in Hawaiian culture. Also, as suggested by the 2012 UHERO report "Foundations for Hawai'i's Green Economy: Economic Trends in Hawai'i Agriculture, Energy, and Natural Resource Management" (Burnett & Wada, 2012), local production and consumption will be tracked by subtracting Hawai'i's agricultural exports from the agricultural production.

Further refinements will incorporate other attempts to value agricultural land in Hawai'i. One study in particular, Goldstein et al (2012), assessed properties held by Kamehameha Schools, comprising 8% of Hawai'i's landbase. Using the InVEST model, the study addressed what land use is best for abandoned agricultural lands. Kamehameha Schools properties on the North Shore exhibited historical, agriculture, aquaculture, and human habitation uses. The model considered redevelopment options including: leaving the area as it is for future development, turning the area to cattle-grazing pasture land, reviving agricultural production, and selling the property for new residential developments. The alternatives were evaluated on three metrics: carbon storage, water quality improvements, and financial returns (Goldstein et al., 2010). By combining the value of agricultural land from the Goldstein et al (2012) valuation of Kamehameha Schools' agricultural holdings with USDA Census of Agriculture ranking of value of agricultural products sold, the per acre value is calculated as $189.03 in 2007 and $187.66 in 2002. For our future purposes, we will consider using this same approach to derive values per acre in Hawaiʻi for all years in which the Census of Agriculture was conducted.

MAʻO Organic Farms, Waiʻanae, Oʻahu
– Courtesy of Kukui Maunakea-Forth ©

Introduction to issue

Hawai'i's forests are vital to the islands' cultural heritage, freshwater supply, economy, carbon footprint and biodiversity. The upland forest is the realm of the gods, or wao akua. As such, the forest, along with the animals and plants residing within the wao akua, is an essential cultural resource. The forest is also the sole water collector and filtration system, providing all of the freshwater needs of the islands, while also reducing sedimentation runoff that would otherwise end up destroying our beaches and coral reefs to the detriment of tourism, a significant cost given that marine-based tourism provides an estimated $800 million in added value to Hawai'i's economy (DLNR, 2011). In addition, the native forest canopy increases the water supply by as much as 30% by extracting water from clouds and fog (DLNR, 2011). Our capacity to mitigate carbon emissions also depends on the forest. The total carbon stock in the average native forest in Hawai'i has been estimated at 34.5 metric tons of CO2 per acre, translating to around 51.3 megatons of CO2 sequestered by the State's forests (DLNR, 2011). Finally, Hawai'i is home to 395 threatened or endangered plants and animal species, a large majority of which rely on a healthy forest ecosystem for food, shelter, and other ecosystem services to survive natural disturbances and a changing climate (DLNR, 2011).

General trends in Hawai'i

Hawai'i's forests are special due to their isolation and high rate of endemic species. Bennett and Friday (2010) estimated the forested area prior to human settlement at around 3.9 million acres (95% of the total land surface). The Polynesians primarily settled in coastal, dry, and mid-elevation forests in the fourth and fifth centuries AD. The biggest changes in forested areas came after European contact in 1778, when large-scale agriculture and cattle ranches were established, followed by urban development (Bennett & Friday, 2010).

Currently, 36% of the islands are forested. However, only 22% of that area is considered "native" forest. The remaining 14% of the forests is overrun with invasive species and considered by many as a "loss of native ecosystem" (Gon et al., 2006). Alien forests are considered less valuable because they are in direct competition with native flora, do not meet the habitat requirements of native fauna and, in some cases, perform ecosystem services less efficiently or even degrade the services. Such is the case with forests infested with strawberry guava (waiawī), which lose 27% more water than pristine forests, in turn reducing water availability (Cook, 2008). Of the 1,490,875 acres of forest, the often cited GAP Analysis of Hawai'i Vegetation in 2006 found: 860,149 acres of native forest, 16,762 acres of mixed native alien forest, 571,781 acres of alien forest and 42,182 acres of unknown forest (Gon et al., 2006).

Many of the ecosystem services provided by forests such as groundwater recharge, water purification, aesthetics, climate control, and habitat provision provide economic value not typically captured by market prices. Kaiser and Roumassett (n.d.) used the Ko'olau conservation district on O'ahu as a case study to examine the total value of forests, including market and non-market uses resulting from direct and indirect uses, as well as non-use values such as existence value. The area is a forested watershed that has been free from development for a century. By looking at the forest resources within the ecosystem as a whole, the authors estimated an annual benefit stream for the Ko'olau conservation district of $165.23 million or $1,690 per acre (with a base year of 1998) (Kaiser & Roumassett, n.d.)

GPI approach

GPI attempts to put a monetary value on the market and non-market aspects of forests, recognizing that forests provide the many ecosystem services that make life possible. GPI aggregates the direct and indirect use values as well as the non-use/intrinsic value of the forest, recognizing that these gifts that the forests provide are degraded as forested lands are converted to other uses. The GPI component for forests is calculated as:

The cost of net forest change = (# acres lost) x (estimated forest value per acre)

Previous GPI studies showed a range of values for forests per acre. Ohio based their forest cover value of $481 per acre on the 2004 Costanza et al. study, while Maryland estimated their forest cover value at $318.50 per acre with total area derived from US Forest Service data. However, Utah used $875 (2000 USD) per acre, based on a study by Dodds et al. (2008) that considered the overall health of the ecosystem in addition to factors used in previous valuation studies. Utah chose to look at the value of wetlands in hand rather than calculating the loss of wetlands. This strategy avoids the problem of selecting a baseline, such as pre-settlement, for which the acreage of forests and the annual increase/decrease are difficult to assess.

GPI-HI approach

Due to the inconsistencies among the data sets available at this point, we were limited in the extent of our analysis of the inventory of forestlands. However, we were able to evaluate a five-year period using NOAA C-CAP data from 2000 (2,177 thousand acres) and 2005 (2,020 acres).

Most of the native flora and fauna found in Hawai‘i's forests are listed as threatened or endangered. Of the 395 species currently red-listed, many, if not all, depend on the forest ecosystems (DLNR, 2012). Due to these unique conditions in Hawai‘i and considering the scarcity of the resource, for the GPI-HI baseline we rejected the estimated chosen by Maryland and opted for the $875 per acre value calculated by Dodds et al. (2008) until additional Hawai‘i-based valuation studies are carried out.

For the GPI-HI baseline we used the following equation:
The cost of net forest change = (# acres lost) x ($875/acre in 2000 USD)

For the year 2005, the cost of net forest cover change for the state of Hawai‘i is valued at $135 million (USD 2000). The average annual cost in the period for which data was available (from 2001 to 2005) is estimated at $217 million (USD 2000).

For a more realistic calculation of area, future GPI-HI efforts will need to develop a time-series data set to plot changes in Hawai‘i's forest cover. Future efforts will harmonize the remote sensing data from: Gon et al (2006); LANDFIRE (a collaboration between US Forest Service and the Department of Interior); the 2010 Hawai‘i Statewide Assessment of Forest Conditions and Resource Strategy (SWARS); and NOAA C-CAP (available for the years 1992, 2000, 2001, and 2005).

In terms of valuation, we will continue to refine the estimate of forest value per acre. There are not many Hawai‘i-focused valuation studies for forests, and the ones conducted to date are fairly limited in geographic scope. Nevertheless, these existing studies do support the idea that Hawai‘i's forests are unique and very precious and thus merit a much higher value.

In Hawai‘i's case, the most significant changes in the forest value are associated with the degree of invasion or control/eradication of invasive species. Above and beyond the factors used to calculate the standard GPI indicator, further development of GPI-HI will need to account for the financial and labor resources used to manage invasive species.

For future efforts, another possibility is to follow the Kaiser and Roumassett (n.d.) valuation methodology and assign the $1690 per acre value (adjusted to 2000 USD). This value can be further adjusted on a population basis, with O‘ahu forests carrying the highest value reflecting demand relative to population size. Prior to utilizing this method however, some of the underlying assumptions need to be re-examined within the Hawaiian context.

Poamoho, O‘ahu – O‘ahu Invasive Species Committee


Axis Deer, Kalaupapa, Molokaʻi – Malia Akutagawa


Destroyed Native Forest, Puʻu Waʻawaʻa, Hawaiʻi – Rick Warshauer ©

Net Forest Cover Change (Cont.)

Nā Pali, Kaua'i – Jeff Berkes ©

Hālawa Valley, Moloka'i - Malia Akutagawa

Benefits of Forest Watershed Protection

- *Optimize production of Hawai'i's fresh water as its primary source*
- *Reduce water shortages*
- *Reduce soil erosion from heavy rains by anchoring soil*
- *Prevent stream pollution and floods through better rainwater absorption and retention*
- *Reduce destructive run-off sedimentation on coral reefs*
- *Reduce debris from swift, flooding streams on beaches*
- *Improve air quality by increasing oxygen production and reducing greenhouse gas emissions by absorbing carbon dioxide*
- *Protect Hawai'i's unique suite of species found nowhere else in the world benefits*

Excerpt from *Wai Fresh Water: From the Mountains to Your Drinking Glass.* Department of Land and Natural Resources Publication, February 2012

Introduction to issue

Scientists have come to the conclusion that the Earth's climate has been warming, and that this warming trend has increased and will continue to do so as a result of human activities that have exponentially increased the amount of certain atmospheric gases. While not the most potent, carbon dioxide traps more of the sun's energy radiating back into space than the other gases, effectively acting like a greenhouse. These greenhouse gases (GHGs), including carbon dioxide, methane, and nitrous oxide, warm the atmosphere sufficiently for life to flourish, but as the concentrations of these greenhouse gases continue to increase the temperature of the Earth's atmosphere and oceans will also continue to rise, changing global climate patterns.

As an island state, Hawai'i is very vulnerable to the effects of climate change. Health risks due to heat stress are very likely to increase with increasing temperatures. Aquatic ecosystems, especially coral reefs, will likely be degraded by increased water temperatures and ocean acidity. Biodiversity of plants and animals associated with Hawai'i's delicate ecosystems is likely to decline. Sea-level rise is very likely to continue at an even faster rate, inundating wetlands and coastal communities, and escalating damages from storm surges.

Climate has both regional and local impacts and costs. The extension of these costs, although shown as increased economic activity as measured by Gross State Product (GSP), actually diminishes both natural and social capital. By internalizing these costs through the Genuine Progress Indicator (GPI), we adjust the GSP to more accurately show their negative impacts as a result of climate change.

General trends

Greenhouse gas emissions are globally distributed. Emissions from one place contribute to damages suffered across the globe. Most measurements are generally done in remote locations such as Mauna Loa, HI which has one of the longest records of direct measurements of atmospheric carbon dioxide (CO_2). The measurements of CO_2 at Mauna Loa Observatory have shown a steadily increasing trend since the 1960s.

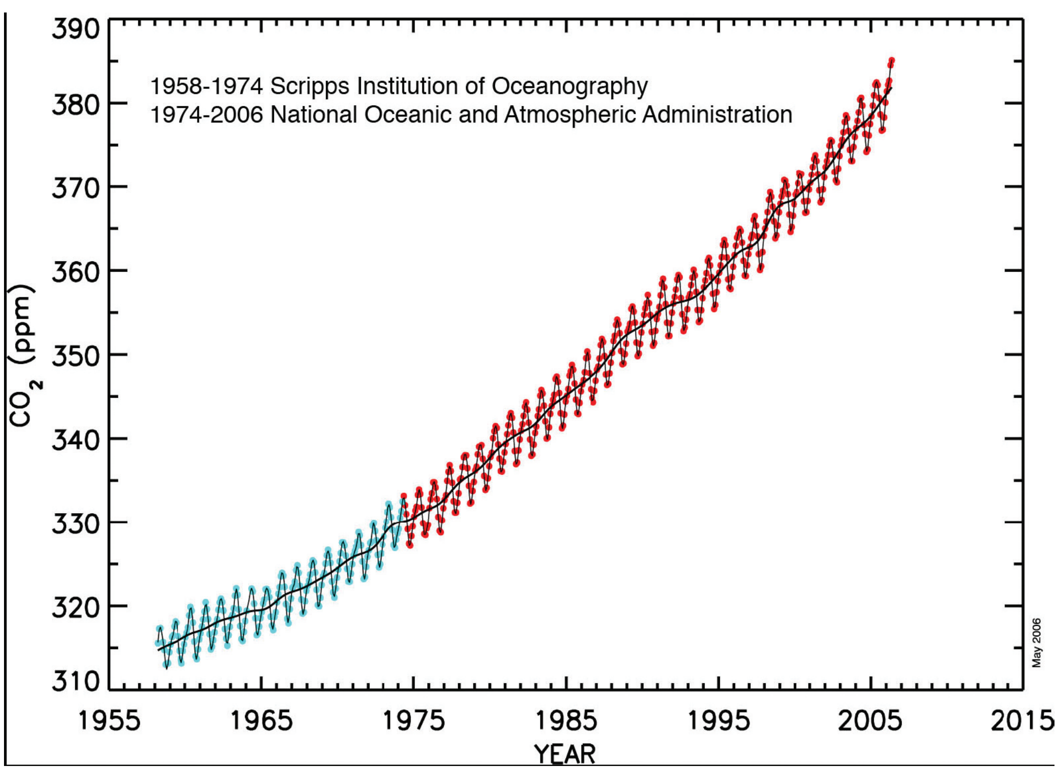


FIGURE 9: Global CO_2 concentration 1955-2015 (NOAA, 2012c): http://celebrating200years.noaa.gov/datasets/mauna/image3b.html

Climate Change

Human activities, intensified by industry, are the main culprit of increased GHGs. Our behavior and consumption patterns are directly related to climate change. Although a global problem, climate change can be addressed locally by focusing on local consumption. Emissions associated with energy consumption are significant, and can serve as a proxy for costs of climate change that are missed by standard accounting (Posner, 2010). The state of Hawaiʻi is a regional contributor of CO_2 emissions that affect the global atmospheric CO_2 concentration measured at Mauna Loa; US EPA reports that the transportation (including aviation) (54%) and energy sectors (36%) are the state's major contributors (see http://www.epa.gov/region9/climatechange/hawaii.html).

According to the DBEDT Data Book for 2011 (DBEDT, 2012), Hawaiʻi's total primary energy consumption has increased from less than 100 trillion BTU in 1960 to 284 trillion BTU in 2008, with an average annual growth rate of 2.3%. Since 1960, Hawaiʻi's strict reliance on petroleum has decreased from 99.7% to 85% in 2008. Meanwhile the use of coal has increased during this time period from 0% to 7.1%, along with renewable energy sources to 7.8%. The majority of renewable energy sources is biomass, followed in distant second by geothermal. Although petroleum use has somewhat declined, total energy consumption has more than doubled in the past 50 years. This increase in consumption has increased CO_2 emissions, contributing further to climate change.

The external costs of greenhouse gas emissions are not incorporated into standard business practice or economic measures such as GSP. Nonetheless, local decision-makers have acknowledged the need to grapple with the causes and impacts of climate change. In 2007, Hawaiʻi passed Act 234 setting the goal to reduce state GHG emissions to 1990 levels by 2020. Based on a GHG emissions inventory published at the end of 2008, the GHG Emissions Reduction Task Force recommended rules to achieve the reductions. In October, 2012, the Department of Health published the draft rules for public comment.

While acknowledged as a threat, the damages Hawaiʻi will suffer from climate change are misrepresented in Hawaiʻi's GSP, often showing up as positive. In terms of adaptation, on July 16, 2009, the State Legislature met in Special Session and enacted Act 20 (Senate Bill No. 266, SD2, HD2, CD1), which established a Climate Change Task Force within the Office of Planning to determine the impacts of climate change trends in Hawaiʻi. In November 2009, a collaborative effort by the Ocean Resources Management Plan Working Group and the University of Hawaiʻi, Center for Island Climate Adaptation and Policy released A Framework for Climate Change Adaptation in Hawaiʻi (Ocean Resources Management Plan Working Group, 2009).

GPI approach

The most common approach to determine the cost of climate change is to look at CO_2 emissions from the consumption of different forms of energy, and to assign those a value. Notably, this method focuses on the value of damages that the state's emissions will cause, regardless of where those damages will occur. (This can be contrasted to a "damages suffered" approach which accounts for the cost of climate change impacts to a state's assets.)

Maryland used the average carbon intensities per British Thermal Unit (BTU) for their four main types of fuel (coal, petroleum, wood, waste, and natural gas) based on the Energy Information Agency (EIA) State Energy Data System. The following values of pounds CO_2 per Million BTU were assumed: 160 for petroleum, 120 for natural gas, 215 for coal, and 197 for waste. Although this is only an approximation, it provides a relatively accurate and reasonably simple methodology for calculating emissions and extrapolating back to the study's baseline year of 1960. These values were then further converted to metric tons of emissions. Maryland's calculations are based on CO_2 only, which provides a low estimate, as it does not include the significant influence of other greenhouse gases.

Maryland based their estimate of the total damage that each ton of emitted CO_2 will cause on a method set out in Talberth, et al. (2007). The method effectively assumed that CO_2 emitted anytime before 1964 caused no damage, because the assimilative capacity of the atmosphere had not been reached. From 1964 onwards, however, the estimated damage a ton of emitted carbon caused rose year by year as the atmosphere became increasingly polluted. This damage estimate includes a wide array of modeled impacts, from coastal property destruction to agricultural production to loss of human life. Following Talberth, et al., Maryland used a cost of

\$89.57 per ton CO_2 (2000 USD) for emissions in 2004; they calculated a linear trend from \$0 in 1963 to \$89.57 in 2004, and extrapolated this trend for 2004-2010. To calculate the annual cost of damages associated with carbon dioxide emissions, then, each year's CO_2 emissions from energy consumption were multiplied by that year's cost per ton of CO_2.

Unfortunately, Talberth et al, and thus Maryland, misinterpreted the baseline study they relied upon for this figure (Tol, 2005) as reporting the cost of carbon in "dollars per ton CO_2" and not as "dollars per ton C," which is correct. This makes a big difference: \$89.57 per ton C is equivalent to \$24.43 per ton CO_2. Tol's published study reviewed dozens of estimates to come up with a median cost of \$14 per ton C and a mean cost of \$93 per ton C (Tol, 2005). Talberth et al. (2007) used the mean of \$93 per ton C, adjusted it to year 2000 dollars to get the \$89.57 value, and incorrectly interpreted it as per ton CO_2. (Tol provided no baseline year for his values, but Talberth reasonably assumed it to be 2004, the year the study was initially published).

GPI-HI approach

To determine the cost of climate change damages caused by emissions in Hawai'i, we calculated the portion of state CO_2 emissions based on energy consumption and multiplied this by Tol's cost per ton CO_2. We used energy consumption data from DBEDT for petroleum, coal, natural gas, and solid waste from 1960 - 1990 in five-year increments, and annually through 2008. For each year, we used Tol's (2005) mean value of \$93 per ton C, translated to \$25.4 per ton CO_2, which we assumed to be expressed in year 2000 USD.

For the year 2009, the cost of climate change for the state of Hawai'i is valued at \$472 million (USD 2000). The average annual cost in the period for which data was available (1960, 1963, 1965-1966, 1970, 1975, 1980, 1982-2009) is estimated at \$384 million (USD 2000).

Future GPI calculations should revisit the carbon calculation, especially regarding the price of carbon, which has been an active area of research since Tol's 2005 study. An altogether alternative approach would be to look at consumer-spending data and assigning a carbon intensity (defined as pounds of carbon emitted per dollar spent) for each category as described in Shammin and Bullard's study (2009). Consumption categories in the analysis could then be far more detailed. For example, in Utah's GPI study (Berik & Gaddis, 2011), consumption categories included food, alcohol, dwellings (owned and rented), lodging, natural gas, electricity, fuel oil, bottled gas, coal, wood, phone, water and sewer, housekeeping, household furnishings, apparel and services, new and used cars/trucks/vans, other vehicles, gasoline, diesel, motor oil, public transportation, air travel, healthcare, entertainment, personal care, education, tobacco, insurance, and miscellaneous purchases.

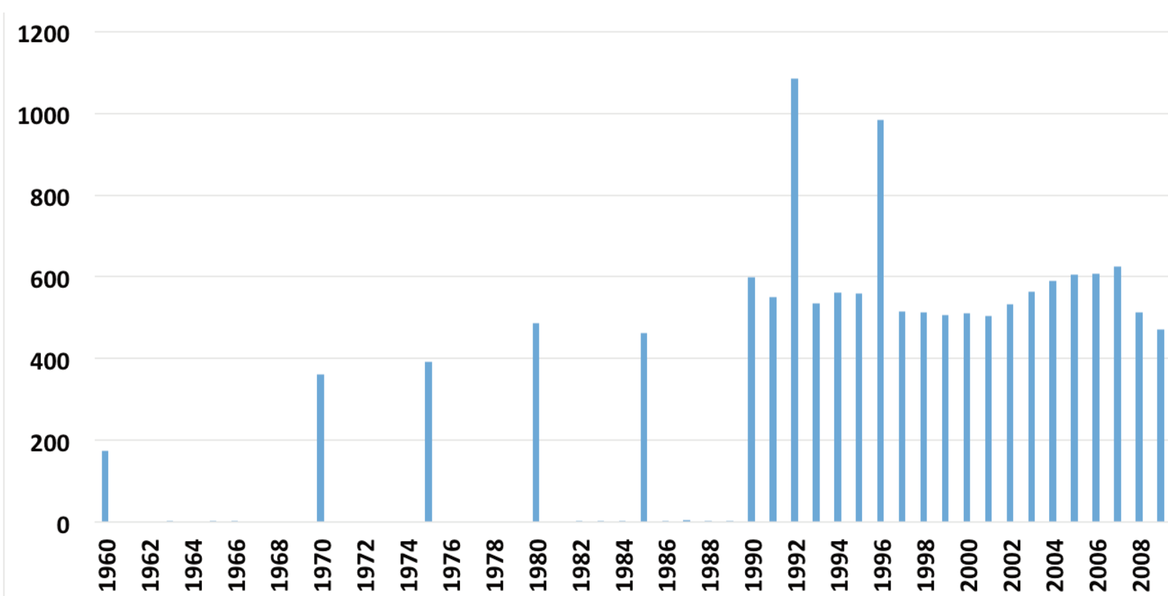


Figure 10. Cost of greenhouse gas emissions for years with emissions data 1960-2009 (million 2000 USD)

cost of Ozone Depletion

Introduction to issue

The stratospheric ozone layer naturally shields the earth from harmful levels of the sun's ultraviolet (UV) rays. Yet decades of emissions of chlorine compounds, such as chlorofluorocarbon (CFCs), have led to a 50-75% depletion of total ozone, resulting in a significant "ozone hole" at the stratospheric level. The ozone hole has steadily grown in size (up to 27 million sq. km.) and duration of existence (from August through early December) over the past two decades (NOAA, 2011). Furthermore, in addition to the hole that regularly appears over Antarctica, in 2011 for the first time in observational record, another hole was detected over the Arctic (Manney et al., 2011).

Without a naturally functioning ozone layer, increasingly harmful levels of UV radiation reach the ground. Greater exposure to UV leads to a variety of health and environmental problems such as (EPA, 2011): increased rates of skin cancer and cataracts (EPA, 2010); decreased plant and crop growth (Fiscus & Booker, 1995); and reductions in phytoplankton production from higher UVB exposure in marine ecosystems (Smith et al., 1992).

Trends in Hawai'i

Since 1987, the Montreal Protocol (ratified by 197 countries), enabled the reductions of over 98% of all global production and consumption of controlled ozone-depleting substances (primarily CFCs). Under the Protocol, the global phase-out of CFCs was achieved by 2010. According to the United Nations Environment Program (UNEP), global observations detect that atmospheric levels of key ozone depleting substances are decreasing, such that the ozone layer should return to pre-1980 levels by 2050 to 2075 (UNEP, 2012).

GPI approach

The overall approach to calculating the annual cost of degradation of the ozone layer follows the method set out by the Utah team (Berrick & Gaddis, 2011). Global CFC emissions levels have been dropping since the enactment of the Montreal Protocol in 1989. These authors set US national ozone emissions as one-third of global emissions based on historical levels, extrapolated from 2003 (the last year with data), then scaled emissions to the state using population. They then assigned a cost of $49,669 per metric ton to account for the damages that a ton of CFC emissions caused or will cause to human health and the environment (Talberth et al., 2007). Talberth et al. claim that UV damages associated with CFCs have a profound and potentially catastrophic effect to justify their cost estimate, although no studies are cited to back this up (Talberth et al., 2007).

Cost of ozone depletion = (tons of emissions of CFCs at national level) x (state population/national population) x ($49,669 (2000 USD) per ton CFC)

GPI-HI approach

For the baseline GPI study for Hawai'i, we followed Utah's lead by extrapolating US share of global emissions in ozone depleting chemicals through 2010 (after which they become negligible), multiplying this by the ratio of Hawai'i's population to the national population, then evaluating the cost by multiplying this by the estimate of damage per ton of CFC as described above.

For the year 2009, the cost of ozone depletion for the state of Hawai'i is valued at $0.067 million (USD 2000). The average annual cost in the period for which data was available (from 1990 to 2009) is estimated at $11 million (USD 2000).

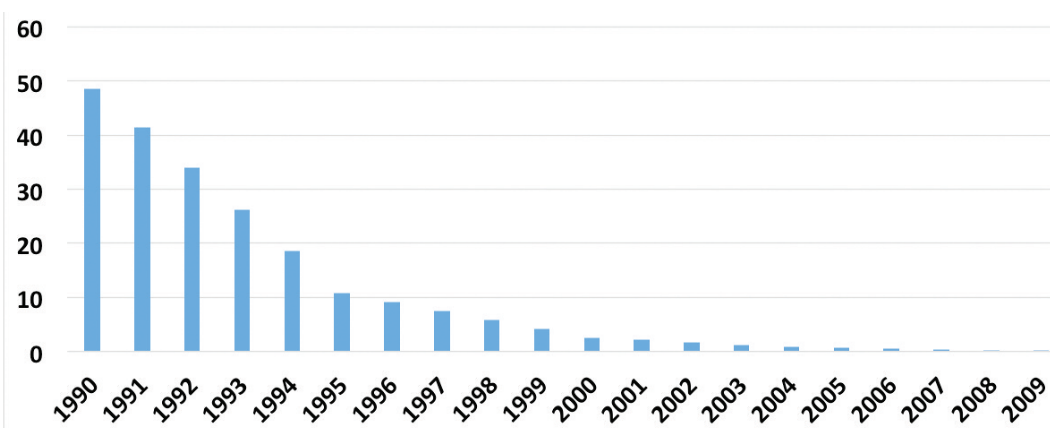


Figure 11. Cost of ozone depletion 2000-2009 (million 2000 USD)

Introduction to issue

Nonrenewable resource depletion is the extraction of fossil fuels and other finite energy sources. At one time, these resources seemed infinite and as accessibility to these resources increased, so did society's dependence upon them. However, by continuously extracting these resources we are depleting finite sources, negatively impacting the environment, and taking away choices and opportunities for future generations. As we are forced to face the ever-increasing needs for energy and tighter environmental constraints, we will need to find renewable energy sources to meet this continuous demand.

General trends in Hawai'i

In 2010, Hawai'i had the third lowest per capita energy use in the nation, thanks to a mild tropical climate that greatly decreases the need for home heating. However, Hawai'i imported 94% of its energy, and as a result had the highest electricity prices in the nation. The highest energy demand in 2010 came from the transportation sector, due in large part to heavy commercial and military aviation fuel use. Petroleum-fired power plants continue to supply more than three-fourths of Hawai'i's electricity generation. Hawai'i is currently the most oil-dependent state in the US with nearly full dependence on fossil fuel imports for its energy needs. Not only is this costly both economically and environmentally, it increases Hawai'i's vulnerability to political, environmental, and economic shocks.

The table below from the State of Hawai'i Data Book for 2011 (DBEDT, 2012) provides a breakdown of Hawai'i's energy consumption in trillions of British Thermal Units (BTUs) and sources since 1970. Hawai'i is still greatly reliant on fossil fuels, but the use of renewable energy sources has increased over the last decade.

Hawai'i has enough potential capacity for renewable energy production to meet its energy demands. According to the National Renewable Energy Laboratory study by Arent, et al. (2009), the state generates 2,414 MW, 83% of which using fuel oil, but has 2,133 MW of new renewable potential and an additional 2,000 MW of rooftop PV system potential. Already, the state ranks among the top ten solar-producing states and produces energy from other renewable sources such as hydroelectricity, geothermal, landfill gas, and other biomass. Hawai'i is also one of eight states with geothermal power generation and ranks third among them in terms of energy generated (EIA, 2009). Hawai'i also has great potential for increased energy efficiency. This could be achieved by retrofitting, as well as construction of "net-zero energy" buildings that produce as much energy as they use each year.

At the state level, in 2010 Governor Neil Abercrombie launched the "New Day in Hawai'i Plan" which aimed to change Hawai'i's energy policies and bolster the state's economy by investing in renewable energies. His initiative built on a 2008 partnership between the U.S. Department of Energy and the state of Hawai'i to launch the Hawai'i Clean Energy Initiative (HCEI). HCEI has two primary objectives: (1) to "conserve, use what we need efficiently and (2) convert, harness what we have wisely" (HCEI, 2010). As a key component to achieving Hawai'i's 70% clean energy goal by 2030 set by HCEI, DBEDT's State Energy Office is working to design policies that support energy-efficiency efforts, renewable energy development, and transportation objectives. Furthermore, there are currently financial programs that

Year	Petroleum	Coal	Biomass	Municipal Solid Waste	Geo-thermal	Hydro-electric	Wind	Photo-voltaic	Solar Hot Water
1970	197		27			1.1			
1980	248		24			0.9			0.8
1990	284	1	18	5	0	1.1	0.3		2.3
2000	20	15	7	5	2.6	0.9	0.2	0.004	3.5
2005	291	16	5	4	2.3	1.1	0.1	0.02	4.5
2008	258	18	9	5	2.4	0.9	2.4	0.15	5.2

Table 5. Hawai'i's Energy by Source (in trillions of BTUs) (DBEDT, 2012)

will help reduce the costs for implementing energy efficiency measures, such as installing solar water heaters, upgrades to energy efficient appliances, and construction. These financial programs include subsidies, grants, loans, rebates, and financial incentives. These programs are offered through a partnership of DBEDT's State Energy Office - Efficiency Branch, Hawai'i Energy (State Energy Conservation Administrator), and the U.S. federal government (DBEDT, 2011).

GPI approach

In order to calculate the environmental and social cost of non-renewable energy resource depletion, GPI multiplies annual energy consumption by the cost of replacing that energy with alternate sources. Maryland, Utah, and Vermont used energy consumption data from the Energy Information Administration (EIA) and converted it as necessary. Ohio and Vermont used past GPI studies that measure the cost of replacing petroleum with ethanol. Their methodology followed valuation studies by Anielski and Rowe (1999), which estimated the cost of replacing fossil fuels with ethanol to be $109.17 per barrel equivalent (2000 dollars) of non-renewable energy used. This cost includes probable externalities associated with massive scaling up of U.S. ethanol production. Maryland more closely followed Makhijani (2007), who estimated the cost of replacing energy from wind and solar energy (50/50 mix) at 8.75 cents per kilowatt-hour and $116 for replacement with biofuels (per barrel equivalent). The solar/wind price was applied to the electricity consumed, while the biofuel costs were used for replacing all other uses of fossil fuels (transportation, industry, etc.). Maryland used the following equation:

Cost of non-renewable energy resource depletion = energy consumption x costs of replacement through alternative sources (e.g., biofuels, wind, solar)

GPI-HI approach

Energy consumption and production at the state level is closely monitored and the data is compiled and made publicly available annually from the U.S. Energy Information Administration (EIA) as well as the State of Hawai'i Department of Business, Economic Development & Tourism (DBEDT). The cost of non-renewable energy resource depletion for the state of Hawai'i can be calculated at this time using the cost of replacement as determined by Makhijani (2007) for wind and solar energy and biofuels.

For the year 2010, the cost of non-renewable energy resource depletion for the state of Hawai'i is valued at $4.998 billion (USD 2000). The average annual cost in the period for which data was available (1980, 1982-2010) is estimated at $4.197 billion (USD 2000).

All of Hawai'i's many forms of alternative power generation should be used in the future to calculate the cost of replacing non-renewable energy sources. Further research into the cost of replacement through geothermal and wave energy should be considered for Hawai'i.

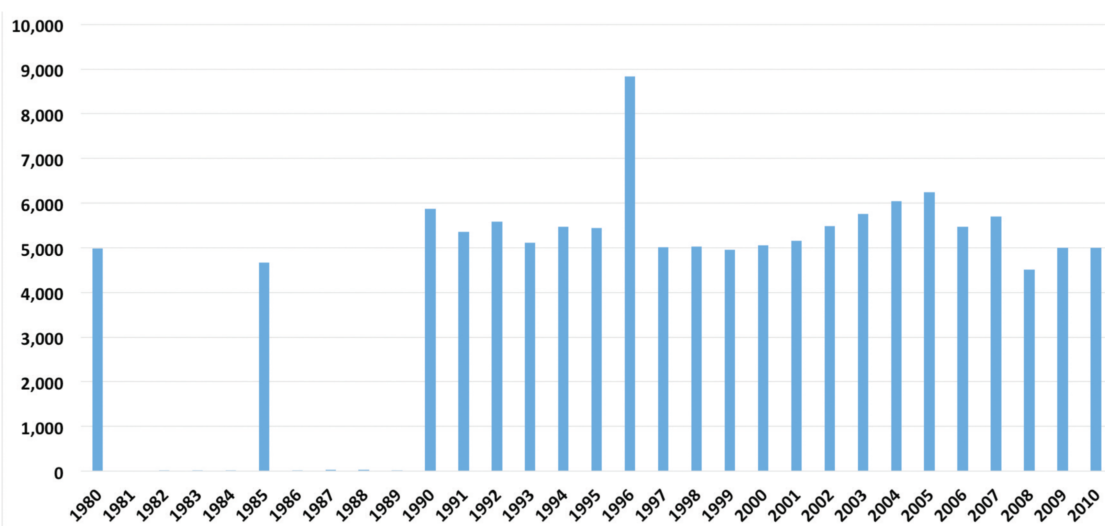


Figure 12. Cost of non-renewable energy resource depletion for years with data (1980 – 2010)

Introduction to issue

Households typically take action to protect themselves and the community against risks from pollution and incur "defensive" expenditures in the process. These defensive expenditures are captured as positive additions to GDP or GSP, even though households are merely compensating for the negative impacts of pollution and not necessarily improving environmental quality. Examples of common defensive expenditures within a household may include water purifiers, air filters, or noise insulation. To get a better idea of how much society pays for protection from pollution, we must first look at the trends in the generation of the types of pollution. Then we can estimate the associated costs for reducing the pollution risks via disposal or abatement methods. Finally, we can deduct this spending from GDP or GSP to give a more accurate reading of social welfare.

The GPI model accounts for the personal expenditures to abate pollution related to air, solid waste, and wastewater at the household level. The methods developed by Costanza et al. (2004) and Bagstad and Ceroni (2007) continue to be the basis for newer GPI studies. GPI identifies common expenditures for pollution abatement that are indicative of air (emission controls on vehicles), solid waste (waste disposal), and wastewater (sewer/septic systems). The costs across the three categories are aggregated to find an estimate of pollution abatement activity, which is then subtracted from the overall GSP.

Air pollution household abatement

The first category, air pollution, can be associated generally with transportation and more specifically with households by way of personal vehicle use. Each personal vehicle is a source of air pollution. An example of a defensive expenditure is a catalytic converter, installed to convert toxic carbon monoxide, unburned hydrocarbons, and nitrogen oxides into less harmful exhaust.

Trends in Hawaiʻi

For Hawaiʻi, the number of passenger vehicle registrations can be found in the State of Hawaiʻi Data Book 2011 (DBEDT, 2012). As seen in the table below, the number of passenger vehicle registrations statewide is variable from year to year, but recently increased 5.5% from 2010 to 2011.

Year	# passenger vehicle registrations	Change from previous year
2003	830,672	--
2004	867,120	+ 4.4%
2005	906,799	+ 4.6%
2006	907,659	+ 0.1%
2007	911,607	+0.4%
2008	903,518	-0.9%
2009	895,770	-0.9%
2010	898,452	+0.3%
2011	951,170	+5.9%

Table 6. Hawaiʻi Personal Vehicle Registrations, 2003-2011 (DBEDT, 2012)

GPI approach

In previous GPI applications, the costs of air pollution abatement were calculated using national or state figures for the number of new passenger vehicles, multiplied by a cost (in 2000 USD) of $100 for a catalytic converter (following the 2004 study by Costanza et al.) plus $8.50 for air filters for each new vehicle (as in the 2007 study by Bagstad and Ceroni). The costs for catalytic converters were added after 1977 since they were not widely used prior to that time (Maryland, 2010). The previous GPI studies all acknowledged that this equipment represents just two of many technologies available to control air emission from cars, so the results serve only as a lower bound for defensive expenditures.

To identify the number of new passenger vehicles in the state, the Maryland GPI team first looked at the change in the stock of registered vehicles from the previous year. Additionally, the team assumed that given a 13-year lifespan on average of a personal vehicle, 7.69% of the stock of registered vehicles will be retired and consequently replaced each year by transferring the registration (Maryland, 2010). These new vehicle figures were multiplied by the costs of catalytic converters and air filters as noted above. The Utah GPI study estimated figures for abatement of auto emissions by linking new car registrations with catalytic converter expenses. In addition, this study matched vehicle miles traveled with air filter costs, assuming replacement every 20,000 miles on average (Berik & Gaddis, 2011).

GPI-HI approach

For the baseline GPI in Hawai‘i, we followed Maryland's example of using the increase in the stock of personal vehicle registrations plus an estimate of the number of retired vehicles; this is assuming that retired vehicles will be replaced by new ones and the existing registration will transfer. We also assumed the same costs for equipment (catalytic converter + air filter) used in the Maryland GPI model. We used the following equation (also based on the Maryland GPI model and in 2000 USD):

Cost of personal pollution abatement for air pollution = # new personal vehicles x ($100 for catalytic converter per vehicle + $8.50 for air filter per vehicle)

In addition to the number of new vehicles, future GPI-HI efforts will expand on the Maryland model to consider the cost of air filters as a function of vehicle miles traveled, disaggregated for personal vehicles. Future GPI-HI tasks will also update the costs for vehicle equipment based on local prices.

Solid waste household abatement

Municipal solid waste (MSW) is a byproduct of our everyday life, generated by every household. As generally defined, MSW includes durable and nondurable goods, containers and packaging, paper, food wastes and green wastes generated by households that may be disposed in municipal landfills. MSW in this definition does not include commercial, construction and demolition, or industrial waste. The costs of waste disposal are borne by households (via service fees and/or assessed taxes), regardless of whether the trash is landfilled, incinerated, or recycled.

Trends in Hawai‘i

Waste management is a unique and particularly important issue in Hawai‘i. Given the economic importance of the tourism industry in the islands, waste management is critical for maintaining aesthetically pleasing landscapes as well as disposing of the additional waste that is generated by visitors. Yet the options for proper disposal of MSW are significantly constrained by the state's limited land area and remote location.

In Hawai‘i, the responsibility for MSW management and residential curbside recycling rests at the city and county levels on each island in the state. Each county has developed its own integrated solid waste management plan outlining collection, diversion, and disposal options ranging from landfilling, to recycling, to composting, to incineration. At the state level, the Office of Solid Waste Management (OSWM) at the Department of Health (DOH) provides statewide guidance, mandates, and funding mechanisms to the county level and regulates landfills and incinerators

The overall objective, at both the city/county and state level, is to achieve higher rates of recycling and reuse. This diversion reduces the volume of waste sent to landfills, incinerators, or waste-to-energy activities. Honolulu City and County, for example, is working to increase its material recycling rate to more than 40% of MSW, compared to current recycling rates ranging from 33.7% in 2007 to 38.7% in 2011 (City and County Honolulu, 2012a). An island-wide curbside recycling program for mixed recyclables and green waste was implemented on O‘ahu in 2010, and although still new, it contributed to reducing the amount of MSW going to the landfill by a full 6% in fiscal year 2011 (City and County Honolulu, 2011). However, constraints on increasing the diversion rate include the size of the on-island market for recyclables and the cost of shipping to other markets (DOH, 2009).

Although each county has a solid waste management plan, Honolulu City and County has the largest volume of MSW to manage, given that approximately 70% of the state's population lives on O‘ahu. The elements of O‘ahu's integrated solid waste management plan are illustrated in the graph below (see www.opala.org for more details) and includes: general materials recycling; H-POWER waste to energy incineration; and landfilling of MSW and incinerator ash at Waimānalo Gulch Sanitary Landfill (WGSL). A plan to ship MSW off-island was never implemented and that waste was later incinerated.

In 2011 on Oʻahu, 26.6% of MSW was sent to WGSL (City and County, 2012a). This landfill received an extension to its original closure date and continues to accept waste while the City and County are exploring other potential landfill sites. In the same year, 34.7% of MSW collected was diverted from the landfill and processed by the H-POWER Waste-to-Energy Facility (City and County, 2012a). The incineration of MSW typically generates 5% of the island's electrical power (Gessel & Langham, 2009). Diversion from the landfill will increase even more once the project to expand capacity at H-POWER by 300,000 tons per year is completed (estimated startup was at the end of 2012). Future plans also include a new composting facility to process sewage sludge, green waste, and food waste. According to the City and County (2012a), the new facility is expected to increase recycling of sewage sludge by an additional 15,000 tons and food waste by an additional 10,000 tons.

GPI approach

Previous GPI studies used per capita solid waste generation and associated costs of disposal to estimate yet another household defensive expenditure. These prior studies examined national trends in per capita solid waste generation, generally based on an EPA calculation of a national average of approximately 4.5 pounds/person/day in 2010 (USEPA 2010). In the cases of absent data at the state level, the Maryland GPI study scaled down national per capita figures according to the ratio of state to national population data (Maryland, 2010). Maryland follows Costanza et al. (2004) by using a cost of $100/ton (in 2000 USD) to dispose of household municipal solid waste; this figure was based on a 1997 study for US EPA.

GPI-HI

For the Hawaiʻi case, figures for per capita solid waste generation were found in three different studies. First, a report for EPA Region 9 estimated a figure of 1.39 tons/person/year averaged across all islands, translating into 7.62 pounds/person/day (Kaufman & Themelis, 2008). An Integrated Solid Waste Management Plan update for the City and County of Honolulu (2008) estimated 1.87 tons/person/year on Oʻahu, which translates into 10.25 pounds/person/day. The State of Hawaiʻi, Environmental Health Administration within the Department of Health estimated 9.2 pounds/person/day statewide in 2008 (DOH, 2010). All three figures are high compared to the 4.5 pounds/person/day cited by the US EPA. However, a direct comparison cannot be made since the national level calculation excludes some materials that are included in the city's tonnage, such as sludge and small amounts of construction and demolition debris (City and County of Honolulu, 2008).

Year	Total MSW (tons)	Landfill (tons)	HPOWER Waste to Energy (tons)	HPOWER Ash and Residue (tons)	General Material Recycling (tons)	Total Landfill Diversion (%)
2007	1,345,632	306,691	396,218	189,351	453,372	63.1
2008	1,313,253	233,065	431,599	191,713	456,876	67.7
2009	1,212,760	178,512	418,618	188,683	426,947	69.7
2010	1,210,417	163,736	418,095	179,946	448,639	71.6
2011	1,241,775	166,921	431,175	163,618	480,061	73.4

Table 7. Municipal solid waste stream on Oʻahu in tons (City and County of Honolulu, 2012a)

For the baseline study for Hawai‘i GPI we used the lowest of the three figures for Hawai‘i -- 7.62 lbs/person/day or 1.39 tons/person/year -- to estimate a lower bound for this indicator in 2008. We utilized the same figure for household costs as Maryland's study, resulting in the following equation:

Cost of personal pollution abatement for solid waste = Hawai‘i state population x 1.39 tons/person/year x $100/ton (in 2000 USD)

Future work on GPI in Hawai‘i will focus on: clarifying the figure for pounds/person/day across the islands given the de facto population (i.e., including visitors). More importantly, we will refine the net costs of disposal per household, taking into account current assessed tax rates, variation in cost for disposal methods other than landfilling, and any by-product revenues from recycling or reuse.

Wastewater household abatement

Wastewater (sewage) is generated from daily activities in households using sinks, toilets, showers, washing machines and dishwashers. Wastewater must be treated before it is released back into the environment to reduce both human health and ecological risks from pathogens, excessive nutrients, and other contaminants. For those households connected to the municipal sewer system, the wastewater flows to a centralized wastewater treatment plant (WWTP) and is subsequently treated and discharged or reused. Other households without connections utilize septic or cesspool systems (also known as individual wastewater systems or IWSs) to collect and dispose of wastewater.

Trends in Hawai‘i

The Hawai‘i Department of Health (DOH) regulates both WWTPs and IWSs for the state. While each relevant city and/or county agency operates WWTPs for its urban and suburban customers, those homeowners in rural locations typically must assume the responsibility of wastewater management.

In 2008, 152 million gallons per day (MGD) of wastewater (including both household and industrial) were treated statewide: 72% treated in the City and County of Honolulu, 17% in Maui County, 6% in Hawai‘i County, and 5% in Kaua‘i County (Center on the Family, 2009). To accommodate for the largest portion of the state's population and resulting wastewater, the City and County of Honolulu operates nine WWTPs and receives between 100 and 110 million gallons of wastewater daily, through a system of 2,100 miles of pipelines and 70 pump stations (City and County of Honolulu, 2012b)

In the state of Hawai‘i, the volume of total wastewater treated has decreased from 150 MGD in 2006 to 141 MGD in 2011 (DOH, 2012b). DOH also tracks the percentage of wastewater reused, refers to the proportion of wastewater that is treated to an appropriate level and then used for irrigation. In 2011, the percentage reused was reported as 13.93%; DOH would like to increase this rate upwards toward 20% by 2015 (DOH, 2012b).

GPI approach

In previous GPI studies, the cost of household abatement for wastewater was calculated using the ratio of households with sewer/septic connections to the total number of housing units multiplied by costs associated with each type of system. Most of these GPI studies used data from the US Census Bureau to estimate the percent coverage by state. Household abatement costs are related to either city and county sewage fees or fees for periodic maintenance of septic systems. Due to variation in sewer rates across the state, Maryland chose a conservative estimate of $4 per 1000 gallons and 91,250 gallons per household per year or 250 gallons per household per day (Maryland, 2010). For onsite treatment, the Vermont (Costanza, 2004) and Maryland (Maryland, 2010) studies assumed new septic systems cost $4000 (in 2000 USD). Costanza (2004) estimated cleaning costs for septic systems at $200 (in 2000 USD). Maryland further assumed that based on a cleaning interval of five years, one fifth of households with septic systems would incur cleaning costs each year.

GPI-HI

The figures for the proportions of Hawaiian households with and without sewer connections vary across sources of information and therefore remain unclear. The US Census Bureau gathered historical data on the number

Personal Pollution Abatement (Cont.)

of household sewer connections in each state from 1940 through 1990. The figures for 1990 show that 80.2% of households in Hawai‘i were connected to sewers, 18.7% utilized septic systems, and 1% used other (US Census Bureau, 1990). Yet the Clean Watershed Needs Surveys conducted by EPA in 2004 and again in 2008 found that the percent of Hawai‘i residents served by WWTPs were 61.9% and 60% respectively (USEPA 2004; USEPA 2008). The remaining households used individual treatment systems for wastewater. A 1999 survey by DOH found that approximately 19% of the households in the state relied upon onsite wastewater treatment (DBEDT, 2008).

In Hawai‘i, residential sewer rates are calculated according to a base charge to cover operation and maintenance costs of the WWTP and a sewer usage charge that varies according to the volume of water used by the household. The rates vary across the different counties, with O‘ahu having the highest. On O‘ahu, for example, the base charge for sewage is $63.23 per unit per month for single family/duplex residences or $43.47 per unit per month for multiple units. On top of the base charge, the sewer usage charge is the cost to collect and treat an average of 80% of the volume of water used by the household and the monthly single family/duplex usage charge on O‘ahu is $3.77 per 1000 gallons (City and County of Honolulu, 2012b). The City & County of Honolulu also provides cesspool services to households not connected to the municipal system at the request of the customer. The city pumps cesspools at a rate of $132.90 per load or fraction thereof (City and County Honolulu, 2012b).

For the baseline GPI-HI, we followed the lead of previous GPI studies, using US Census Bureau figures for percent household connections (approximately 80%). Likewise, we used the following equation (based on Maryland), retaining the same cost figures but adapting the model for the number of households in Hawai‘i:

Costs of personal pollution abatement for wastewater = (# of households with sewer connections) x ($ typical sewer fees per year) + (# of households with septic systems) x 1/5 x ($ for pumping)

Future GPI efforts will aim to find a more recent figure for the proportion of households with sewer connections, as well as refine the costs to better reflect what typical households in Hawai‘i pay for this defensive expenditure.

For the year 2010, the cost of personal pollution abatement for the state of Hawai‘i is valued at $357 million (USD 2000). The average annual cost in the period for which data was available (from 1990 to 2010) is estimated at $318 million (USD 2000).

The table below summarizes the total costs for all defensive expenditures accounted for in the GPI model.

Personal Pollution Abatement of:	Parameters	Average Annual Cost $ Billions (2000 USD)	Cumulative Cost $ Billions 1990-2010 (2000 USD)
Air pollution	# new vehicles; associated costs of pollution control equipment	0.10	2.11
Municipal solid waste (MSW)	MSW per capita; population; associated costs of waste management	0.17	3.60
Wastewater	# households disaggregated by sewer vs. septic systems; associated costs of management	0.14	2.87
Combined		**0.318**	**6.69**

Table 8. Defensive expenditures accounted for in GPI

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For The Keiki
– Evan Tector ©

Introduction to issue

Coral reefs are one of the most diverse, rich, dense, and productive ecosystems on Earth (Bishop et al., 2011; Needham, 2010). Yet they are also under threat from anthropogenic activity, be it directly from overuse from tourism and recreation (Cesar & van Beukering, 2004a) or more indirectly from climate change and nutrient pollution (Needham, 2010). Hawaiian reefs draw more than 11 million visitors annually, sustain subsistence fisheries, and dissipate wave energy that have the potential to damage coastal property and threaten human life (Cesar & van Beukering, 2004a). High quality reefs increase property values of nearby residential, rental, and lodging properties. Reefs provide habitat for fish and marine mammals and produce sand, which in turn creates beaches. The biodiversity of the reefs themselves generate significant research activity, which also brings in millions of dollars each year in research funds spent in the state. According to another study (Cesar et al., 2002 as cited in Cesar & van Beukering, 2004a), the 1,660 km2 of coral reef ecosystems around Hawai'i contribute $360 million annually to the state economy, constituting an estimated overall asset value of approximately $10 billion. This represents the composite value of all ecosystem services, or benefits, that coral reefs provide to society, including tourism, fisheries, amenity value, and biodiversity, but does not include intrinsic value.

General trends

Kaiser et al. (2002) noted coral reefs in Hawai'i are younger, simpler, and may be more vulnerable to disease than other reefs globally. Stress and damage to coral reefs can impact tourist satisfaction and reduce Hawai'i's natural capital in the long term. In a study by Jokiel et al. (2004), from 1999 to 2002 monitored sites in Maui, O'ahu, and Moloka'i detected declines in the area of coral cover up to 6%. Kaho'olawe and Kaua'i had moderate increases in coral cover, however, at rates less than 2%. Most of the declines are concentrated in areas with high human populations and heavy sedimentation (Jokiel et al., 2004). In Maunalua Bay, O'ahu, for example, the volume and residence time of polluted waters and sediments have increased because of human activity, leading to the collapse of the coral population throughout the area (Wolanski et al., 2009).

The National Oceanic and Atmospheric Administration (NOAA) maps the state's coral reefs by remote sensing, but that can be spotty. Many individual sites are monitored and assessed on a regular basis, yet more comprehensive data representing coral reefs across the entire state are not available. The Hawai'i Institute of Marine Biology's Coral Reef Assessment and Monitoring Program (CRAMP) has 60 permanent stations across the Hawaiian islands that have been surveyed at least twice over a four year period since 1999 (Jokiel et al., 2004). The Nā Pali Coast, Hanalei, and Poi'pū on Kaua'i; West O'ahu, Waikīkī, Kāne'ohe Bay, Hanauma Bay, and Pūpūkea on O'ahu; South Moloka'i; West Maui, Mā'alaea Harbor on Maui; Kaho'olawe; Kona Coast, Kawaihae Harbor, and Hilo Bay on Hawai'i are of particular interest and have been the subject of study for CRAMP (CRAMP, 2012). The state Department of Land and Natural Resources (DLNR) and its Division of Aquatic Resources (DAR) are the agencies responsible for managing coral reefs in Hawai'i, and have identified a list of areas of concern under threat from anthropogenic activity (CRAMP, 2012).

GPI approach

Not included in the GPI, coral reefs present a unique asset of particular value for the state of Hawai'i. The notion of including coral reefs as another "land" type is supported by the traditional Hawaiian land management concept *ahupua'a*, according to which entire watersheds including submerged reefs were considered as one single management area (Cesar et al., 2002). Similar to how the application of the GPI in Utah included an additional grasslands indicator unique to the region (Berik & Gaddis, 2011), this assessment will account for the change in coral reef cover to tailor the indicator to Hawai'i.

GPI-HI approach

In adapting the GPI to Hawai'i, the goal is to capture the value of coral reefs in the state. A GPI should consider the cost to society of net coral reef cover change. Ideally, the GPI would monitor the gains and losses in coral area cover as well as the health and quality of the reefs, which determine the type and level of ecosystem services reefs provide. Together with local valuation studies that attempt to measure the reefs' value to society, it is then

Submerged Coastal Systems

possible to construct the value of coral reefs as a GPI component.

Similar to how GPI arrived at component scores for change in land cover, the cost of change in coral cover could initially be estimated by:

The cost of net coral cover change = (# acres lost) x (estimated coral cover value per acre)

Initially, the focus can be placed on just the area of coral cover change, regardless of habitat health and quality. The number of acres of coral cover change will need to be compiled from local sources. A set of 2007 coral cover area data produced by the NOAA Coral Reef Conservation Program is currently available, and further data may be available from the Pacific Islands Benthic Habitat Mapping Center covering different years. To date, we have not identified more recent data, and spatial coverage is relatively spotty.

The estimated value of coral cover per acre must then be estimated. Using Cesar and van Beukering's (2004b) estimate of approximately $360 million/year for 1,660 km2 of coral reef ecosystems around Hawai'i, a simplistic, initial valuation would be to use the average value of an acre of reef in the state applied to all reefs statewide. Future studies can then refine this estimate with a richer and more expansive spatial dataset, expanding on Cesar and van Beukering's ecological-economic model that links ecological indicators with the value of ecosystem services.

Continued monitoring and economic valuation efforts are necessary for making a more complete assessment of coral reefs in the state, particularly regarding the cover and condition of the entirety of coral reefs. A statewide ecological-economic model needs to be built that links coral reef area and conditions with ecosystem service flows and values in a spatially explicit manner.


ʻŌmilu – Victoria Martocci ©


Heʻe – Victoria Martocci ©


Super Sucker, Kāneʻohe Bay, Oʻahu – Kaneko Uchino ©

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Conclusions

This initial, preliminary exercise to calculate Hawai'i's GPI had a number of goals. First, we aimed to demonstrate policy relevance of GPI in part by showing how it is a more holistic indicator than GSP that can better guide sustainable policy. We used GPI to identify environmental trends, such as the costs of water pollution, greenhouse gas emissions, and land conversion. We also commenced the compilation of a centralized data repository of existing data. Relatedly, we identified data gaps and research needs to strengthen GPI's comprehensiveness and reliability.

Policy relevance

GPI is an exercise to aggregate environmental, social, and economic changes into one, common indicator that reflects social progress. This aggregation can offer important insights into the state's economy; it also enables comparison across seemingly incommensurate policy goals, such as farmland preservation and income equality. Comparing GPI year after year can give interested stakeholders an idea of how "sustainable" the state is.

Our provisional calculations show that economic growth in the productive sectors of the economy, which is what is reflected in GSP, has come at a cost of environmental depletion and degradation. With the exception of the global economic crisis in 2009, Hawai'i's Gross State Product has been increasing each year over the past decade, but environmental costs of this economic production have not been insignificant (Figure 13).

Future work in the coming year will further adjust the standard GSP-like indicators with other economic and social changes. The resulting GPI figure can then directly be contrasted to GSP. Results will likely show that economic growth trends are tempered by associated social and environmental changes. Policy makers interested in building a sustainable economy need to reflect on the various environmental, social, and economic changes that are not considered in GSP. The GPI enables policy makers to understand the trade-offs posed by economic development.

Due to our tourism-based economy and geographic isolation, Hawai'i is highly dependent on its natural resource base. The GPI exercise, while preliminary, offers some insight into the magnitude of the costs of environ-

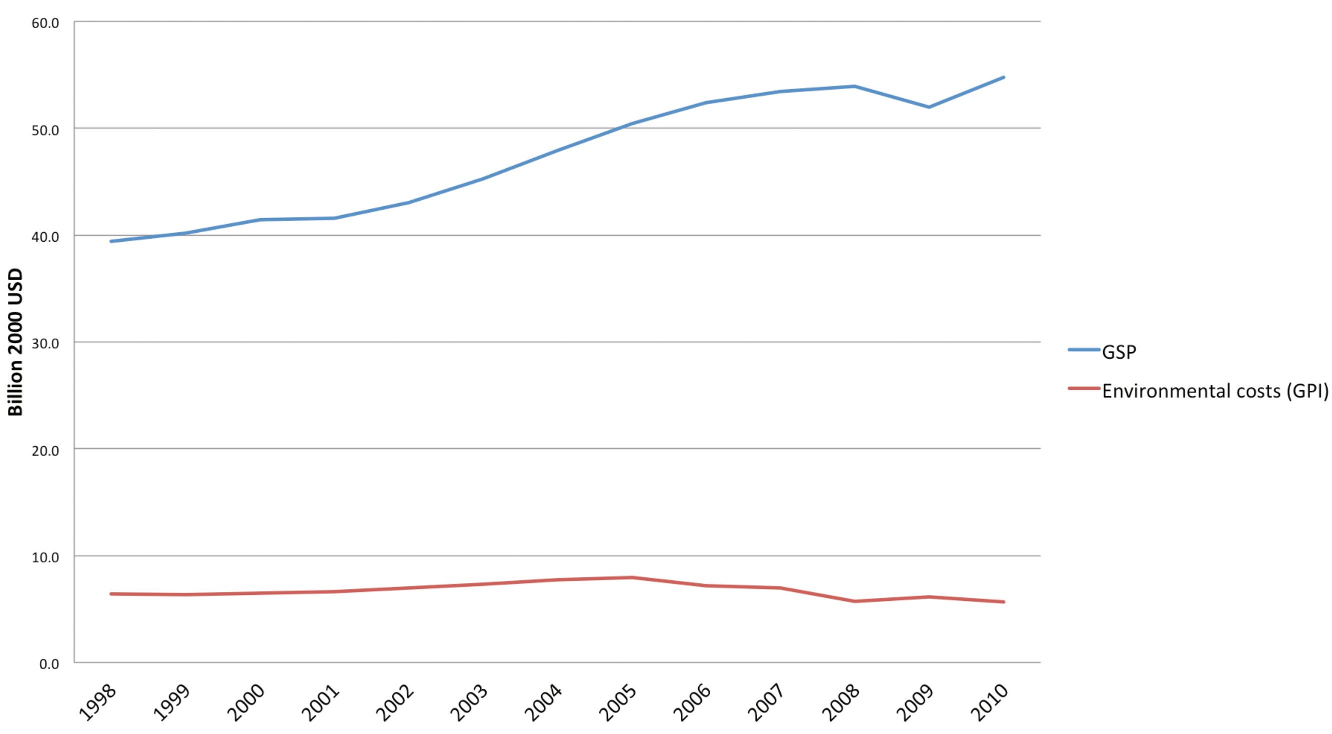

Figure 13. Hawai'i GSP and environmental costs [billion 2000 USD]

mental depletion and degradation that the state incurs. These costs often go unaccounted for in policy because they are not bought and sold on a market, and they are dispersed across society as opposed to being concentrated on particular groups. Nonetheless, the costs are real -- greenhouse gas emissions are causing global warming; nonrenewable energy resource depletion implies more scarcity in the future; conversion of farmland implies less food security and aesthetic quality; and loss of forests, coral reefs, wetlands, and other natural areas result in less ecosystem service production.

It is important to note the limitations of these preliminary calculations. Data were scarce, at times requiring interpolation between sparse data points or shortened time horizons. Furthermore, we adapted the state of Maryland's GPI model for Hawai'i, at times using mainland data and valuations; future research will help tune the method to the local Hawaiian context.

GPI: Major contributors and trends

Based on the GPI calculations, in the year 2000, the state of Hawai'i faced environmental degradation costing over $6.2 billion (2000 USD) (Figure 14) or an estimated $5,595 per capita for that year. The bulk of this loss was due to depletion of nonrenewable energy resources ($5.1 billion); the other GPI components are at least an order of magnitude smaller. This finding reflects the fact that Hawai'i is one of the most oil-dependent states in the nation. This represents the environmental and social cost of using nonrenewable energy instead of renewable sources, such as wind and solar.

Looking across a longer timeframe, the average total annual cost of environmental degradation was $5.2 billion. The average cost for each indicator in Figure 15 represents the average of the years for which there were data.[1]

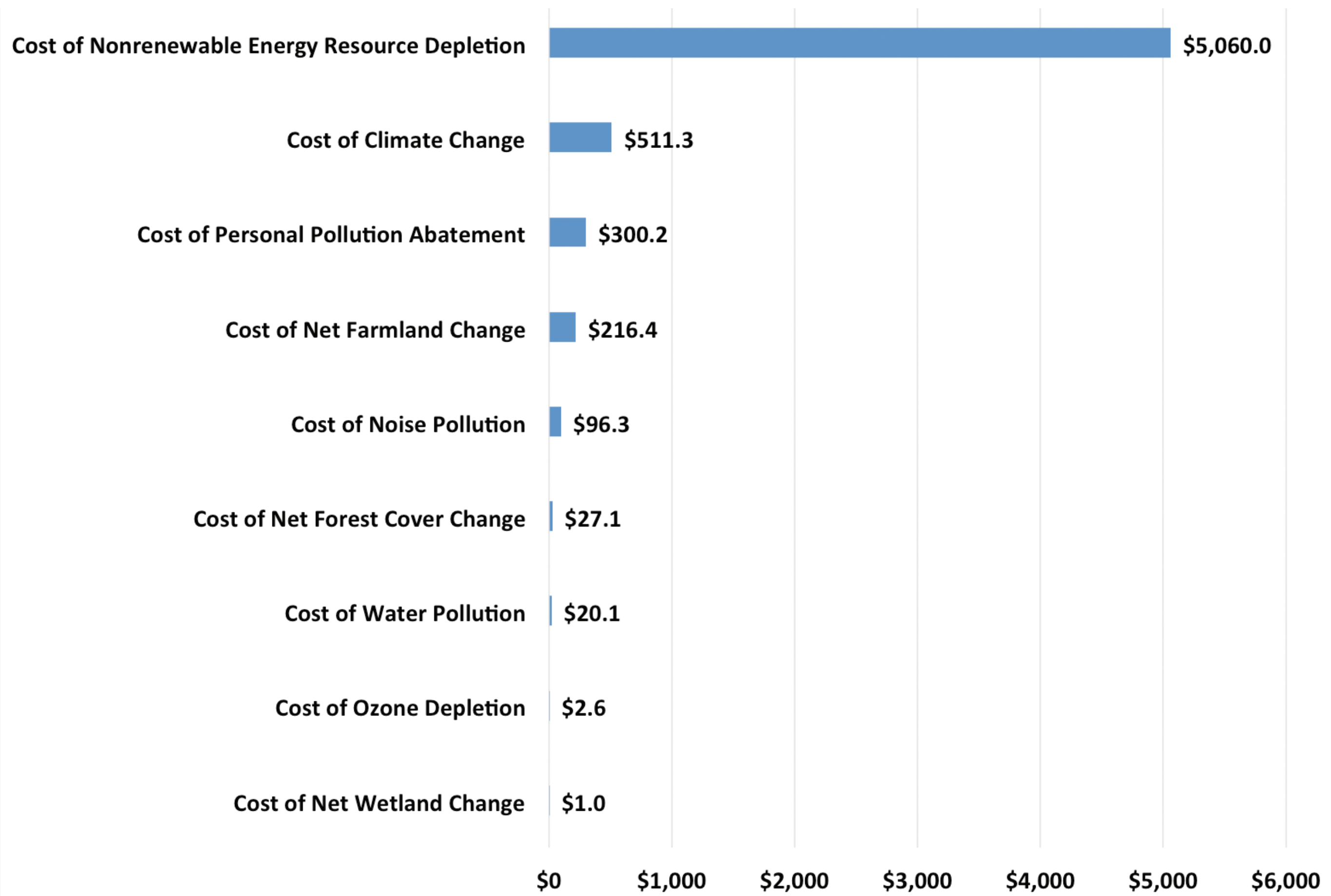

Figure 14. Environmental costs in year 2000 [million 2000 USD]

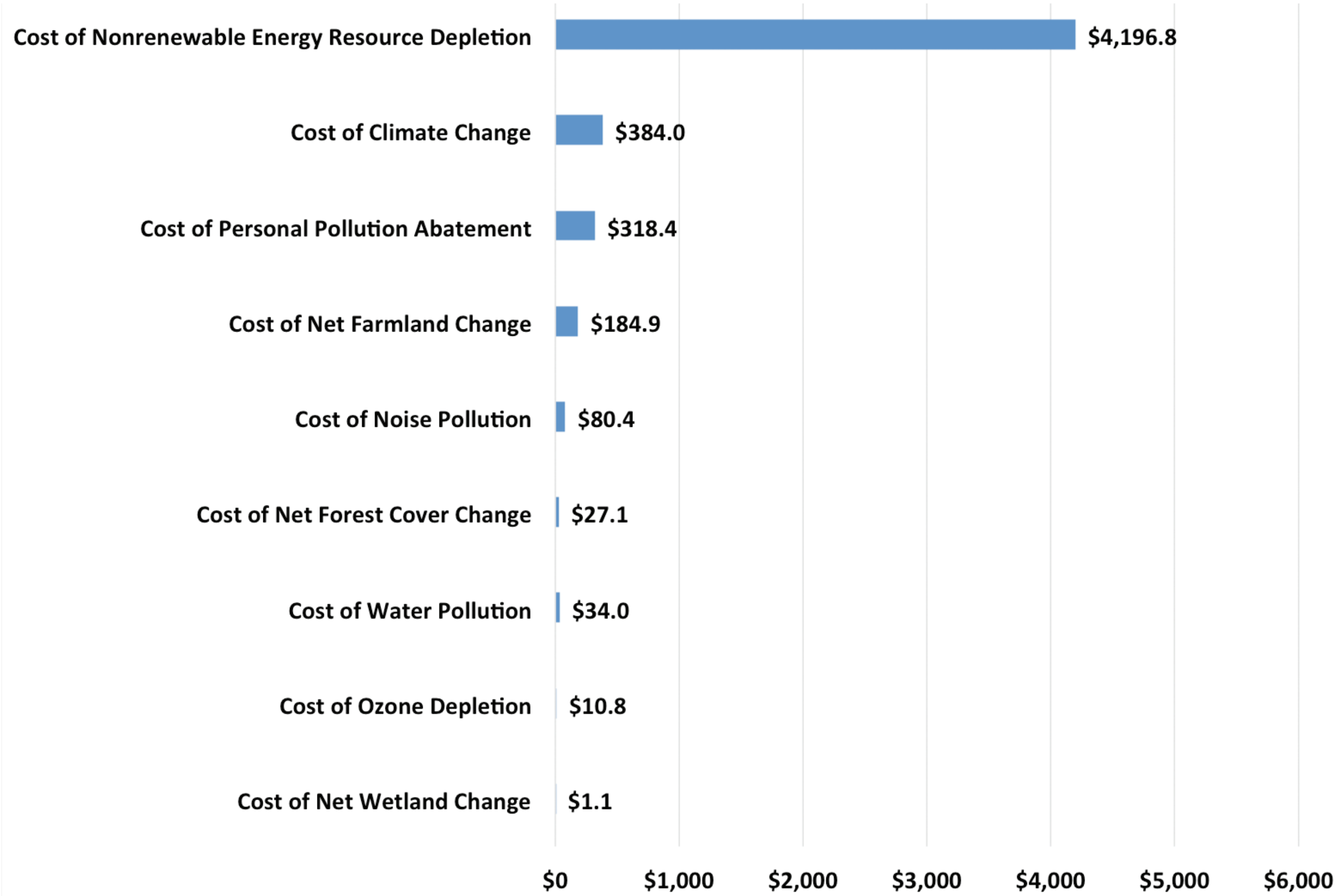

Figure 15. Average cost of environmental degradation

Clearly, the state's reliance on fossil fuels constitutes the largest portion of environmental costs. Environmental pollution was also a significant cost. Personal expenditures spent to protect oneself from pollution, such as air filters, drinking water purification, and solid waste disposal, cost Hawaiians an average of $318.4 million per year. Many of the indicators trend upwards over the years for which there are data. For example, the cost of noise pollution has risen as Hawai'i has urbanized; costs to avoid pollution have risen as population has grown; and steadily more costs have been incurred each year due to increasing farmland loss since 1984 and forest loss since 2001. Notable exceptions to this persistent upward trend are ozone, which phased out due to international policy, and an encouraging slight downward trend over the past few years in the costs of nonrenewable energy resource depletion and climate change, though this was likely driven by the global economic crisis.

Data: repository, gaps, and research needs

One of the objectives of this initial baseline exercise was to commence a data repository of useful environmental indicators. We located numerous sources of data across state and federal agencies, and compiled the data into an Excel spreadsheet. Part of the effort was to perform a baseline inventory of data required for a full-fledged GPI exercise in the coming years. This exercise has gathered some initial data on many of the key components of GPI, but reveals a number of data and knowledge gaps. For example, no data exist past year 2000 on wetland areas in Hawai'i; data on land uses are conflicting and their coverage temporally and spatially is spotty; and the extent and health of coral reefs have yet to be assessed statewide.

Recommendations (Cont.)

There is obvious value to using a standardized methodology to calculate state-level GPI; state GPIs can be directly compared. That said, the measure is meant to capture the change in wellbeing due to social, economic, and environmental changes at the state level. This speaks to the need to tailor the methods to the local context, in terms of the components considered (e.g., adding coral reefs as a type of natural capital), the local conditions (e.g., considering the impacts of naturally occurring vog) and values assigned (e.g., recognizing the scarcity of certain resources in Hawaiʻi due to its isolation). Moreover, GPI's components and valuation methods ignore important Hawaiian values, for example the cultural importance of some of the land use changes, in terms of traditional use or symbolism of natural resources, agriculture, natural resource management, ahupuaʻa, and so forth.

Next steps

Our team's intent is to build on this work over the coming years. One major effort during 2013 will be to complete the remaining components of the GPI model. This initial exercise concentrated on the environmental components of GPI, leaving to another day the social and economic indicators. Moreover, in building on and evaluating other states' GPI calculations, we recognized a number of methodological improvements which we have incorporated in our calculations for Hawaiʻi, for example, regarding the cost of ozone pollution and the cost of carbon emissions. We will discuss these errata with experts in the other states.

A number of the environmental components of GPI need to be amended or expanded to the Hawaiian context. For example, for water quality, we used local data on the percentage of streams considered impaired to calculate the water pollution component of GPI. We did not consider coastal water quality, however; beach closure days certainly should be incorporated as a cost of poor water quality. Other GPI components now draw on national-level datasets, while localized data would give a more accurate accounting. Further, we will consider whether other natural assets important for Hawaiians' wellbeing should be included; for example, we added change in area of coral reefs to the GPI model, but did not have sufficient data to undertake the calculation.

A related research need is to conduct localized valuation studies that capture the cost of changes in each environmental indicator, such that they accurately reflect the cost to society. For example, in considering coastal water quality, we would like to conduct a valuation study that assesses the cost of beach closures in terms of tourism dollars lost, recreational benefit foregone, and fisheries. The value of clean streams currently draws on national figures, and needs to be localized. A further example would be to assess the value of wetlands in Hawaiʻi; wetlands host biodiversity, protect coastal property from wave energy, filter sediment from storm water runoff, and mitigate floods. The value of wetlands in Hawaiʻi will likely be far different than in Maryland, Utah, or elsewhere.

Ulupō Heiau, Kailua, Oʻahu – Bruce Behnke ©

Recommendations (Cont.)

Outside of research needs and goals for the short term, the team from Hawai'i Pacific University and University of Hawai'i Mānoa plan to build awareness about the environmental, social, and economic contributors to well-being, using GPI to illustrate magnitudes and trends. The research team will employ the model to encourage discussion among state agencies and other stakeholders to not only raise awareness but also create a sense of ownership of the GPI concept. The team will use stakeholder input and expertise to better refine the method, particularly in terms of data collection and adapting the components to the local context. Further, the team will seek to connect the GPI exercise to state priorities. We foresee that the GPI exercise can add value to, reinforce, and help evaluate the outcomes of many of the state's sustainability policy priorities, including the Governor's "A New Day" initiative, DLNR's "The Rain Follows the Forest", the Hawai'i 2050 Sustainability Task Force's objectives, the Hawai'i Clean Energy Initiative, and diverse watershed and smart growth community management plans. A major effort over the coming year will be dedicated to building a constituency who can contribute to and use the GPI.

The research team will be building a website that disseminates the GPI results, drawing on Maryland's example. All data will be available, linked to their original sources. As the data.Hawai'i.gov initiative takes hold, we hope that the original sources of data used in calculating GPI will be easily available to the public and we will simply link to them. The GPI website, hosted at CTAHR at UH Mānoa, will disseminate the data during the intermediate time the state database is being populated. The website will also enable the public to access reports and publications, analyze the current GPI calculation, and run scenarios.

Hale o Lono Heiau, Waimea Valley, O'ahu – Hi'ipaka LLC ©

Mōlī - Forest & Kim Starr ©

Mōlī brooding chick – Rob Shallenberger ©

Mōlī (Laysan albatrosses) spend the non-breeding season (July to October) 10-20 miles offshore hunting for squid, fish eggs, crustaceans, and fish. They return to land only to breed and raise their young. Over 70 percent of the world's population of Laysan albatrosses nests on Midway in the Northwestern Hawaiian Islands.

AIRNow.gov (n.d.) AIRNow. Retrieved from: http://airnow.gov/index.cfm?action=airnow.local_state&stateid=12&tab=0

American Lung Association (2012). State of the air 2012. Retrieved from: http://www.stateoftheair.org/2012/msas/Honolulu-HI.html#ozone

Anielski, M., Griffiths, M., Pollock, D., Taylor, A., Wilson, J., & Wilson, S. (2001). Alberta sustainability trends 2000: Genuine Progress Indicators report 1961 to 1999. Pembina Institute for Appropriate Development. April 2001.

Anielski, M. & Rowe, J. (1999). The Genuine Progress Indicator - 1998 Update. San Francisco, CA: Redefining Progress.

Arent, D., Barnett, J., Mosey, G., & Wise, A. (2009). The potential of renewable energy to reduce the dependence of the state of Hawaii on oil. Proceedings of the 42nd Hawaii International Conference on System Sciences, (pp.1-11).

Bagstad, K. J., & Ceroni, M. (2007). Opportunities and challenges in applying the Genuine Progress Indicator/Index of Sustainable Economic Welfare at local scales. International Journal of Environment, Workplace and Employment, 3(2), 132. doi:10.1504/IJEWE.2007.017880

Bagstad, K. J., & Shammin, M. R. (2012). Can the Genuine Progress Indicator better inform sustainable regional progress—A case study for Northeast Ohio. Ecological Indicators, 18, 300–341.

Bennett, K. and Friday, K. (2010). Criterion 1 Indicator 1: Area and percent of forest ecosystem type, successional stage, age, class, and forest ownership or tenure. Unpublished manuscript. Hilo, Hawaii: US Forest Service.

Berik, G., & Gaddis, E. (2011). The Utah Genuine Progress Indicator, 1990 to 2007: A report to the people of Utah. Available at: www.utahpop.org/gpi.html

Bishop, R. C., Chapman, D. J., Kanninen, B. J., Krosnick, J. A., Leeworthy, B., & Meade, N. F. (2011). Total economic value for protecting and restoring Hawaiian coral reef ecosystems. NOAA Technical Memorandum CRCP 16.Brander, L. M., Florax, R. J. G. M., & Vermaat, J. E. (2006). The empirics of wetland valuation: A comprehensive summary and a meta-analysis of the Literature. Environmental & Resource Economics, 33(2), 223–250. doi:10.1007/s10640-005-3104-4

Brauman, K.A., Daily, G.C., Duarte, T. K., & Mooney, H.A. (2007). The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. Annual Review of Environment and Resources, 32(1), 67–98. doi:10.1146/annurev.energy.32.031306.102758

Buddenhagen, C.E., Chimera, C., & Clifford, P. (2009). Assessing biofuel crop invasiveness: a case study. PloS one, 4(4), e5261. doi:10.1371/journal.pone.0005261

Burnett, K., & Wada, C. (2012). Foundations for Hawai‘i's green economy: Economic trends in Hawai‘i agriculture, energy, and natural resource management. Honolulu: University of Hawai‘i Economic Research Organization.

Center on the Family. (2009). Quality of life in Hawaii: 2009 report. University of Hawaii Center on the Family and Hawaii State Department of Business, Economic Development & Tourism (DBEDT). December 2009. Retrieved from: http://www.uhfamily.hawaii.edu/publications/brochures/QualityOfLifeInHawaii2009.pdf

Cesar, H.S.J., van Buekering, P., Pintz, S., & Dierking, D. (2002). Economic valuation of the coral reefs of Hawaii: Final report. University of Hawaii for the Hawaii Coral Reef Initiative Research Program and NOAA, Coastal Ocean Program. Retrieved from: http://www.coralreef.gov/meeting18/evhcri_samoa_2007.pdf

Cesar, H. S. J., & van Beukering, P. (2004a). Ecological Economic Modeling of Coral Reefs Evaluating Tourist Overuse at Hanauma Bay and Algae Blooms at the Kīhei Coast Hawaii. Pacific Science, 58(2), 243–260.

Cesar, H. S. J., & van Beukering, P. (2004b). Economic Valuation of the Coral Reefs of Hawai'i. Pacific Science, 58(2), 231–242. doi:10.1353/psc.2004.0014

City and County of Honolulu. (2008). City and county of Honolulu integrated solid waste management plan update: October 2008. Department of Environmental Services. Retrieved from: http://www.opala.org/solid_waste/pdfs/Draft_Revised_ISWMP_Update.pdf

City and County of Honolulu. (2011). Curbside recycling program evaluation and strategic planning: Phase I. Department of Environmental Services, November 2011. Retrieved from: http://www.opala.org/solid_waste/pdfs/curbside_recycling_eval_nov2011.pdf

City and County of Honolulu. (2012a). Recycling and landfill diversion. Department of Environmental Services. Retrieved from: http://www.opala.org/solid_waste/archive/facts2.html

City and County of Honolulu (2012b). Sewer service charges. Department of Environmental Services. Retrieved from: http://www1.honolulu.gov/env/wwm/faq/sewer_service_charges.htm

City and County of Honolulu. (2012c). Wastewater systems. Department of Environmental Services. Retrieved from: http://www1.honolulu.gov/env/wwm/

Conry, P., Mann, S., Cannarella, R. & Akashi, Y. (2008). Hawaiʻi Spatial Analysis Project. Honolulu: Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife.

Cook, N., Stephens, L. (2008) Waiawi are water hogs, Hawaii Tribune Herald, Wawaii Association of Watershed Partners. Retrieved from: http://hawp.org/_library/documents/watershed-resource-page/waiwai%20water%20hogs.pdf

Coral Reef Assessment and Monitoring Program [CRAMP]. (2012). Hawaiʻi Institute of Marine Biology. Retrieved from http://cramp.wcc.hawaii.edu/http://www.green.maryland.gov/mdgpi

Costanza, R., Erickson, J., Fligger, K., Adams, A., Adams, C., Altschuler, B., Balter, S., et al. (2004). Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden County and Burlington, from 1950 to 2000. Ecological Economics, 51(1-2), 139–155. doi:10.1016/j.ecolecon.2004.04.009

Costanza R. et al. (2009). Beyond GDP: The need for new measures of progress. Pardee Papers no. 4. Pardee Center for Study of the Longer-Range Future.

Daly, H., Cobb, J. (1989) For the common good: Redirecting the economy toward community, the environment and a sustainable future. Boston: Beacon Press.

Data.Hawaii.gov. (2012). Department of Health Environmental Indicators. Retrieved from: https://data.hawaii.gov/Health/Table-9-Percentage-of-Population-served-Safe-Drink/h53f-wetv?

Demos (2012, May 9) Vermont establishes a genuine progress indicator, blazes a path for measuring what matters. Retrieved from http://www.demos.org/press-release/vermont-establishes-genuine-progress-indicator-blazes-path-measuring-what-matters

Dodds, W., Wilson, K., Rehmeier, R., Knight, G., Wiggam, S., Falke, J., and Bertrand, K. (2008). Comparing ecosystem goods and services provided by restored and native lands. BioScience, 58(9). 837-845.

Environmental Council. (2012). State of Hawaii annual report on the environment 2011. Honolulu, Hawaii: Hawaii State Department of Health, Office of Environmental Quality Control.

Fiscus, Edwin L., and Fitzgerald L. Booker. "Is increased UV-B a threat to crop photosynthesis and productivity?." Photosynthesis Research 43.2 (1995): 81-92.

Freeman, A.M. (1982). Air and water pollution control: A benefit cost analysis. New York, NY: John Wiley and Sons.

Gessel, G. & Langham, S. (2009). Handling Oahu's Waste Disposal. North American Waste-to-Energy Conference. Paper no. NAWTEC17-2346, 181-186. http://dx.doi.org/10.1115/NAWTEC17-2346

Goldstein, J. H., Caldarone, G., Duarte, T. K., Ennaanay, D., Hannahs, N., Mendoza, G., Polasky, S., et al. (2012). Integrating ecosystem-service tradeoffs into land-use decisions. Proceedings of the National Academy of Sciences of the United States of America, 109(19), 7565–7570. doi:10.1073/pnas.1201040109

Gon, S., Allison, A., Cannarella, R., Jacobi, J., Kaneshiro, K., Kido, M., Lane-Kamahele, M., Miller. S., (2006). A GAP Analysis of Hawaii. US Geological Survey (CD-ROM distributed by the University of Hawaii, Honolulu, Hawaii)

Gutrich, J., Donovan, D., Finucane, M., et al. (2005). Science in the public process of ecosystem management: Lessons from Hawaii, Southeast Asia, Africa and the US Mainland. Journal of Environmental Management, 76. 197-209.

Hawaii 2050 Sustainability Task Force. (2008). Hawaii 2050 sustainability plan: Charting a course for Hawaii's sustainable future. Honolulu, HI: State of Hawaii 2050 Sustainability Task Force.

Hawaii Clean Energy Initiative [HCEI]. (2010). Retrieved from Hawaii Clean Energy Initiative: http://www.hawaiicleanenergyinitiative.org/

Hawaii State Department of Business, Economic Development & Tourism [DBEDT]. (2008). Onsite wastewater treatment survey and assessment. March 2008.. Retrieved from: http://www.state.hi.us/dbedt/czm/program/doc/Onsite_Wastewater_Treatment.pdf

Hawaii State Department of Business, Economic Development & Tourism [DBEDT]. (2011). Powering up: A special report on energy in Hawaii. Honolulu, HI: DBEDT. Retrieved from: http://energy.hawaii.gov/wp-content/uploads/2011/08/Powering-Up-A-Special-Report-on-Energy-in-Hawaii.pdf

Hawaii State Department of Business, Economic Development & Tourism [DBEDT]. (2012). State of Hawaii Data Book 2011. Honolulu, HI: DBEDT. Retrieved from: http://hawaii.gov/dbedt/ info/economic/databook

Hawaii State Department of Health [DOH]. (2009). Report to the 25th Legislature, State of Hawaii 2010: Solid waste management. Office of Solid Waste Management. Retrieved from: http://gen.doh.hawaii.gov/sites/LegRpt/2010Rpt/Solid%20Waste%20Management.pdf

Hawaii State Department of Health [DOH]. (2010). Indicators of environmental health. Honolulu, HI: Environmental Health Administration. Retrieved from: http://hawaii.gov/health/environmental/env-planning/goals/goalsandindicators.html /indrpt2010.pdf

Hawaii State Department of Health [DOH]. (2011). Noise program: Indoor and Radiological Health Branch. Retrieved from: http://hawaii.gov/health/environmental/noise/noisesection/noise.html

Hawaii State Department of Health [DOH]. (2012a). 2008/2010 State of Hawaii water quality monitoring and assessment report: Integrated report to the U.S. Environmental Protection Agency and the U.S. Congress pursuant to Section §303(d) and §305(b), Clean Water Act (P.L. 97-117). (3 July 2012). Honolulu, Hawaii: The Hawaii State Department of Health.

Hawaii State Department of Health [DOH]. (2012b). Environmental health management report 2012. Honolulu, HI: Environmental Health Administration, December 2012 (Draft). Retrieved from: http://hawaii.gov/health/ environmental/env-planning/goals/ EHMA_Report_12_20_12.pdf

Hawaii State Department of Health [DOH]. (2012c) State of Hawaii annual summary: 2011 air quality data. Honolulu, HI: Author. Retrieved from: http://hawaii.gov/health/environmental/air/cab/cabmaps/pdf/2011_aqbook.pdf

Hawaii State Department of Land and Natural Resources [DLNR]. (1997). Hawaii water plan. Honolulu, HI: Commission on Water Resource

Management. Retrieved from: http://hawaii.gov/dlnr/cwrm/planning_hiwaterplan.htm

Hawaii State Department of Land and Natural Resources [DLNR]. (2010). Hawaii statewide assessment of forest conditions and trends: 2010. Honolulu, HI: Division of Forestry and Wildlife. Retrieved from: http://hawaii.gov/dlnr/dofaw/SWARS/home

Hawaii State Department of Land and Natural Resources [DLNR]. (2011). The rain follows the forest, hahai no ka ua i ka ululāʻau: A plan to replenish Hawaii's source of water. Honolulu, HI: Author. Retrieved from: http://hawaii.gov/dlnr/chair/pio/nr/2011/The-Rain-Follows-the-Forest.pdf

Honolulu Board of Water Supply. (2004). Safe drinking water status report. Retrieved December 4, 2012 from: http://www.hbws.org/cssweb/display.cfm?sid=1080

Jokiel, P. L., Brown, E. K., Friedlander, A., Rodgers, S. K., & Smith, W. R. (2004). Hawaiʻi Coral Reef Assessment and Monitoring Program: Spatial patterns and temporal dynamics in reef coral communities. Pacific Science, 58(2), 159–174. doi:10.1353/psc.2004.0018

Kaiser, B., Krause, N., Mecham, D., Wooley, J., & Roumasset, J. (n.d.). Environmental valuation and the Hawaiian economy. Honolulu: University of Hawaii Economic Research Organization. Retrieved from http://www.uhero.hawaii.edu/assets/HawaiiEnviroEvaluation.pdf

Kaiser, B., & Roumasset, J. (2002). Valuing indirect ecosystem services: The case of tropical watersheds. Environment and Development Economics, 7(04), 701–714. doi:10.1017/S1355770X02000426

Kaufman, S.M. & Themelis, N.J. (2008). Detailed examination of the flows of solid waste through three EPA Region 9 states. New York, NY: Earth Engineering Center, Columbia University. Retrieved from: http://www.epa.gov/region9/waste/solid/projects/pdf/ColumbiaFinal-reportJune20.pdf

Lawn, P. & Clarke, M. (2008) Sustainable welfare in the Asia-Pacific: Studies using the Genuine Progress Indicator. Northampton, MA: Edward Elgar.

Leung, P.S. & Loke, M.K. (2002). Agriculture's contribution to Hawaii's economy—An update. Honolulu, HI: Cooperative Extension Service, CTAHR, University of Hawaii at Manoa.

Leung, P.S. & Loke, M.K. (2008a). Economic impacts of improving Hawaii's food self-sufficiency. Honolulu, HI: University of Hawaii, Economic Impacts; E1-16.

Leung, P.S. & Loke, M.K. (2008b). The contribution of agriculture to Hawaii's economy: 2005. Honolulu, HI: Cooperative Extension Service, CTAHR, University of Hawaii at Manoa.

Makhijani, A. (2007). Carbon-free and nuclear-free. A roadmap for U.S. energy policy. Takoma, MD: IEER Press.

McGuire, S., Posner, S., & Haake, H. (2012). Measuring prosperity: Maryland's Genuine Progress Indicator (GPI). Solutions 3(2), 50-58.

Manney, G.L., Santee, M.L., Rex, M., Livesey, N.J., Pitts, M.C., Veefkind, P., Zinoviev, N.S. (2011). Unprecedented Arctic ozone loss in 2011. Nature (2011), doi:10.1038/nature10556

Maryland State Government (2010). Maryland Genuine Progress Indicator. Retrieved from http://www.green.maryland.gov/mdgpi

Muller, N. Z. & Mendelsohn, R. (2009). Efficient pollution regulation: Getting the prices right. American Economic Review 99(5): 1714–1739. Retrieved from: http://www.aeaweb.org/articles.php?doi=10.1257/aer.99.5.1714.

National Oceanic & Atmospheric Administration [NOAA]. (2011). Stratosphere: Southern Hemisphere Ozone Hole. Retrieved from http://www.cpc.ncep.noaa.gov/products/stratosphere/sbuv2to/ozone_hole.shtml

National Oceanic & Atmospheric Administration [NOAA]. (2012a). Land Cover Analysis Hawaii Land Cover. Retrieved from http://www.csc.noaa.gov/crs/lca/hawaii.html

National Oceanic & Atmospheric Administration [NOAA]. (2012b). Land Cover Analysis Pacific Regional Data. Retrieved from http://www.csc.noaa.gov/ccap/pacific/

National Oceanic & Atmospheric Administration [NOAA]. (2012c). Mauna Loa Carbon Dioxide Record. Retrieved from: http://celebrating200 years.noaa.gov/datasets/mauna/image3b.html

Needham, M. D. (2010). Value orientations toward coral reefs in recreation and tourism settings: a conceptual and measurement approach. Journal of Sustainable Tourism, 18(6), 757–772. doi:10.1080/09669581003690486

New Economics Institute. (2011). Measuring for the Future : an Overview of Measurements of Progress and Sustainability on the State-Level (pp. 1–30).

Nordhaus, W. &Tobin, J. (1971). Is growth obsolete? In: Moss, M. (ed.) The measurement of economic and social planning. Washington, DC: National Bureau of Economic Analysis.

Ocean Resources Management Plan Working Group. (2009). A framework for climate change adaptation in Hawaii. State of Hawaii's Office of Planning, Coastal Zone Management (CZM) Program, University of Hawaii's Center for Island Climate Adaptation and Policy (ICAP). Retrieved from: http://icap.seagrant.soest.hawaii.edu/sites/ seagrant.soest.hawaii.edu/files/publications/climate_change_adaptation_framework_2009_2.pdf

Page, C., Bony, L., & Schewel, L. (2007). Island of Hawaii Whole System Project Phase I Report. Boulder, CO: Rocky Mountain Institute. 2007: 27-29.

Posner, S.M. (2010). Estimating the Genuine Progress Indicator for Baltimore, MD. Master's of Science Thesis, University of Vermont, Burlington.

Posner, S. M. & Costanza, R. (2011). A summary of ISEW and GPI studies at multiple scales and new estimates for Baltimore City, Baltimore County, and the State of Maryland. Ecological Economics 70, 1972-1980.

Shammin, M. & Bullard, C. (2009). Impact of cap-and-trade policies for reducing greenhouse gas emissions on U.S. households. Ecological Economics, 68 (8-9), 2432–2438.

Smith, Raymond Calvin, et al. "Ozone depletion: ultraviolet radiation and phytoplankton biology in Antarctic waters." Science 255.5047 (1992): 952-959.

Talberth, D.J., Cobb, C., & Slattery, N. (2007). The Genuine Progress Indicator 2006: A tool for sustainable development. Oakland, CA: Redefining Progress.

Tol, R. S. J. (2005). The marginal damage costs of carbon dioxide emissions: an assessment of the uncertainties. Energy Policy, 33(16), 2064–2074. doi:10.1016/j.enpol.2004.04.002

United Nations Environment Program [UNEP]. (2012). Retrieved from: http://www.unep.org/ Documents.Multilingual/Default.asp? DocumentID=2694&ArticleID=9272&l=en

US Census Bureau. (1990). Historical census of housing data: Sewage disposal. Retrieved from: http://www.census.gov/hhes/www/housing/census/historic/sewage.html

US Census Bureau. (2011). 2010 Census Urban and Rural Classification and Urban Area Criteria. Retrieved from: http://www.census.gov/geo/ reference/urban-rural-2010.html

US Geological Survey [USGS]. (2012). National Gap Analysis Program (GAP) Land Cover Data. Retrieved from: http://gapanalysis.usgs.gov/ gaplandcover/data/download/

US Department of Agriculture [USDA]. (2009). Summary Report: 2007 National Resources Inventory, Natural Resources Conservation Service, Washington, DC, and Center for Survey Statistics and Methodology, Iowa State University, Ames, Iowa.

US Department of Agriculture [USDA]. (2010). Hawaii Annual Statistics Bulletin. National Agricultural Statistics Service (NASS). Retrieved from: <http://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Annual_Statistical_Bulletin/index.asp>

US Department of Agriculture [USDA]. (2012). Census of Agriculture. Retrieved from: http://www.agcensus.usda.gov/Publications/index.php

US Department of the Interior [DOI]. (2012)., Landscape Fire and Resource Management Planning Tools. Retrieved from: http://www.landfire.gov/vegetation.php

US Energy Information Administration [EIA]. (2009). Hawaii state energy profile. Washington, DC: Author. Retrieved from: http://www.eia.gov/beta/state/print.cfm?sid=HI

US Environmental Protection Agency [EPA]. (n.d.) Agricultural economic overview. Retrieved at: http://www.epa.gov/agriculture/ag101/printeconomics.html

US Environmental Protection Agency [EPA]. (2004). Clean watersheds needs survey 2004: Report to Congress. Office of Water. Retrieved from: http://water.epa.gov/scitech/datait/databases/cwns/2004reportdata.cfm

US Environmental Protection Agency [EPA]. (2008). Clean watersheds needs survey 2008: Report to Congress. Office of Water. Retrieved from: http://water.epa.gov/scitech/datait/databases/cwns/upload/cwns2008rtc.pdf

US Environmental Protection Agency [EPA]. (2010a). Municipal solid waste generation, recycling and disposal in the United States: Facts and figures for 2010. Retrieved from: http://www.epa.gov/osw/nonhaz/municipal/pubs/msw_2010_rev_factsheet.pdf

US Environmental Protection Agency [EPA]. (2010b). Health effects of overexposure to the sun. EPA 430-F-10-026. Retrieved from: http://www.epa.gov/sunwise/uvandhealth.html

US Environmental Protection Agency [EPA]. (2011). "Health and environmental effects of ozone layer depletion". Website: http://www.epa.gov/ozone/science/effects/index.html

US Environmental Protection Agency [EPA]. (2012a). Clean energy and climate change. State Activities: Hawaii. Retrieved from: http://www.epa.gov/region9/climatechange/hawaii.html

US Environmental Protection Agency [EPA]. (2012b). Municipal solid waste. Office of Solid Waste. Retrieved from: http://www.epa.gov/osw/basic-solid.htm

US Environmental Protection Agency [EPA]. (2012c). Noise pollution. Office of Air and Radiation. Retrieved from: http://www.epa.gov/air/noise.html

Van den Bergh, J. (2009). The GDP paradox. Journal of Economic Psychology 30, 117-135.

Wolanski, E., Martinez, J. A., & Richmond, R. H. (2009). Quantifying the impact of watershed urbanization on a coral reef: Maunalua Bay, Hawaii. Estuarine, Coastal and Shelf Science, 84(2), 259–268. doi:10.1016/j.ecss.2009.06.029

Hawai'i State Environmental Council
2012 Annual Report

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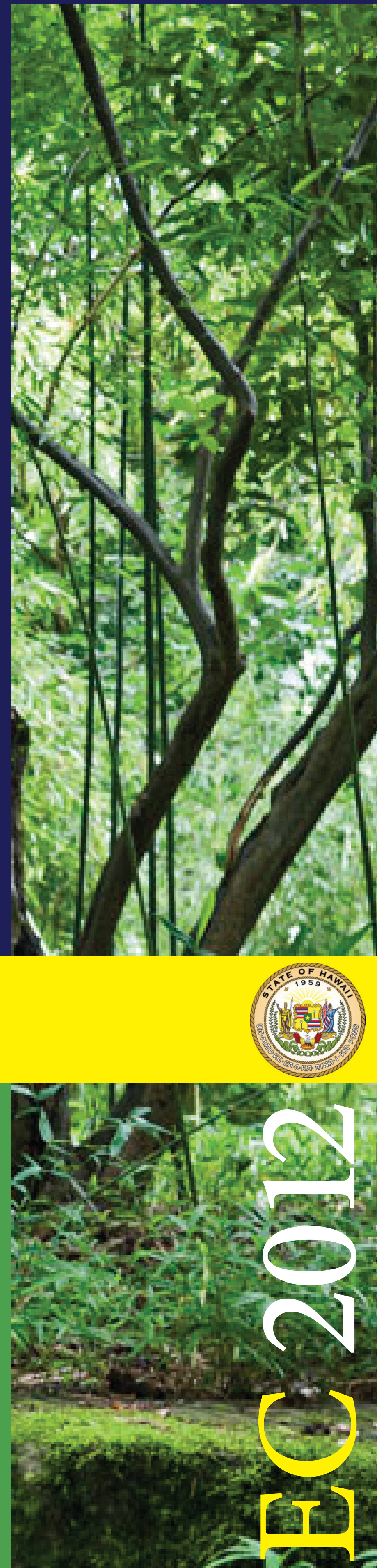
*Every aspect of our lives is intertwined
with the natural resources of our islands.
Our survival is literally dependent on proper stewardship.
A strong economy is not one based on unfettered consumption
of our natural resources, but instead one that is
sustainable over time.*

*– Governor Neil Abercrombie,
A New Day in Hawai'i*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