

Relating ecosystem services to domains of human well-being: Foundation for a U.S. index

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ABSTRACT

Humans are dependent upon the services provided by nature, and unless we effectively account for the range of values from ecosystems in our efforts to protect the environment, we cannot sustain human well-being. In light of this dependence, a national measure of well-being is needed which is responsive to changes in the provisioning of ecosystem services as well as service flows from economic and social sectors. To conceptualize the eco-human linkages we must identify the measurable components of well-being that can be related to ecosystem service provisioning. The indicators and metrics used in existing well-being indices provide a basis for developing a core set of domains to develop such a composite measure of well-being; however these indices lack the ability to link well-being endpoints specifically to service flows from different types of capital. This paper suggests a core set of well-being domains that can be linked to ecosystem services via their relationship to economic, environmental and societal well-being. The well-being domains identified will serve as the foundation for developing an index of well-being for the U.S. which will be used to evaluate the provisioning of ecosystem, economic and social services in a predictive modeling framework. We present an overview of selected well-being measures and discuss the potential relationships between ecosystem services and the domains selected to develop the index structure.

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1. Introduction

Over the past 30 years, quality of life research has garnered increasing attention as important value-added “good life” measures for national policy (Cummins, 1996; Hamilton, 1999; Diener, 2000; Hagerty et al., 2001; Cummins et al., 2003; Costanza et al., 2004; Gundelach and Kreiner, 2004; Layard, 2006; DiTella and MacCulloch, 2006; Welsch, 2006, 2007; Pannozzo et al., 2009). However, people’s determination of what constitutes the good life has been largely ignored by governments and decision makers (Diener et al., 2008). Measures of human welfare that respond to specific policy aspects are needed to track trends over time for government accountability. Well-being measures are most often linked to economic and social policy objectives and the notion of progress. Quite often, environmental drivers are excluded from human well-being accounts despite the fact that the environment plays a vital role in quality of life (Deutsch et al., 2003; Hirschberg et al., 1998; Smyth et al., 2008; Cox et al., 2006; Wainger and Price, 2004; Levinson, 2009; MEA, 2005; Rahaman et al., 2005; Folke

et al., 1996). Because there is no agreed upon definition of human well-being evaluating policy effectiveness and the implications of alternative decisions in context of the economy, the environment and social conditions can become a daunting task.

A fuller accounting is necessary to measure the influence of environmental policies on aspects of societal welfare and overall human well-being, relative to economic, social and political factors. Alternative, integrated concepts of progress are needed to better understand the human condition and its collective relationship to service flows from the economic, social and environmental sectors. More specifically, local, regional and national policy makers lack the information to better understand how decisions may impact the delivery of ecosystem goods and services that are important to overall human well-being. Viewed through a lens of sustainability, the contributions of ecosystem services to elements of environmental, economic and societal well-being in terms of basic needs and subjective well-being (SWB) become clearer (Summers et al., 2012). Human well-being, as an endpoint measure for evaluating changes in ecosystem services, captures what people need and want to maintain or improve quality of life. A composite index of well-being is a much needed metric for environmental accountability towards a sustainable society. An index for the U.S. that is responsive to changes in ecosystem services, if conceptualized in

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terms of existing well-being measures could serve as a valuable measure for understanding the potential impact of environmental decisions.

Many indices fail to distinguish the differences between drivers of well-being and derived societal benefits. When the drivers and endpoints of well-being are not considered separately, targeted decision making becomes difficult and often ineffective. Our work developing a proposed well-being index for the U.S. considers human well-being as a state of the human condition described by objective and subjective measures of health and quality of life which can be inherently linked to the provisioning of services. It is important to note that this index will describe the state of the human condition rather than the quality and quantity of services that contribute to that state. By doing so, we will be able to distinguish between ‘means’ and ‘ends’ measures for the development of a predictive model which utilizes a well-being index as an endpoint. We are suggesting a snapshot of well-being (current well-being assessment) which can be evaluated over time based on the provisioning of three types of services—economic, ecosystem and social—that affect different aspects of people’s lives (sustainability) as suggested by Stiglitz et al. (2009).

This paper suggests a core set of well-being domains that can be linked to ecosystem services via their relationship to economic, environmental and societal well-being. The well-being domains identified will serve as the foundation for selecting and developing indicators to construct a composite well-being index for the U.S. which will be used to evaluate the provisioning of ecosystem, economic and social services. We present an overview of selected well-being measures and discuss the potential relationships between ecosystem services and the domains selected to develop an index structure.

2. A cross-section of well-being measures

An extensive literature review was conducted to develop domains descriptive of well-being in the U.S. which could be linked to ecosystem, economic and social services provisioning. Well-being measures selected for review were inclusive of domains representing different combinations of the elements of basic needs, subjective well-being, economic well-being and environmental well-being at various spatial scales for different populations (Table 1). Many of these measures, in addition to a number of other indices of societal progress are described on the *WikiProgress* website, a global information platform intended to facilitate the development of new measures based on economic, social and environmental factors (OECD, 2011b).

Although economic in nature, terms such as “capital” and “goods and services” offer robust labels for grouping the many monetary and non-monetary factors that influence well-being. There is sufficient literature, such as Vemuri and Costanza (2006), to suggest that a balance among four types of capital—human, built, social and natural—is the most likely to correlate for achieving individual and community well-being. Goods and services may be grouped within these capital categories to describe supply. For this paper the discussion focuses on the linkages between provisioning of these goods and services and human well-being.

The basic human needs element dominates well-being measures. This is not surprising since basic human needs must be met before holistic well-being can ultimately be achieved (Maslow, 1954; Max-Neef, 1992; Sen, 1993; Diener and Diener, 1995; Costanza et al., 2007; Dodds, 1997). The ability to meet basic needs is most often evaluated using economic metrics; however, a multitude of progress measures support the threshold hypothesis suggesting that developed countries abandon the growth objective in favor of sustainability by integrating environmental and social

externalities necessary for national welfare accounting (Eckersley, 2000; Costanza et al., 2009). Kulig et al. (2010) offer a summary of such composite indicators used as corrections of national account aggregates. Additionally, national accounts of well-being and progress should be augmented by alternative concept measures of welfare which include household information, education and health investments, government activities and environmental assets and services (Abraham and Mackie, 2005; Matthews, 2006; EU, 2005). Measures such as the Genuine Progress Indicator (GPI), for example, account for ecosystem losses and pollution costs, which may have a negative impact on overall well-being despite an increase in Gross Domestic Product (GDP) (Talberth et al., 2007).

The majority of measures of progress defined in economic terms for developed countries have largely ignored SWB (Hupport et al., 2009), even though happiness has been proposed as the ultimate goal of progress (Eckersley, 2000). The value of quantitative measures of subjective well-being, according to Stiglitz et al. (2009) “hold the promise of delivering not just a good measure of quality of life per se, but also a better understanding of its determinants, reaching beyond people’s income and material conditions.” Identifying the linkages between ecosystem goods and services and SWB is key to understanding the intrinsic value of natural systems.

Our desire to have clean water and air, minimal exposure to contaminants, acceptable levels of biodiversity, and environmental conditions that are significantly distant from ecological tipping points (e.g. stability, sustainability, climate change, sea level rise) all play a role in how we value ecosystems in terms of our overall well-being (Summers et al., 2012; Louv, 2005). The environmental element of human well-being, coupled with our innate connection to nature, supports the need to evaluate ecosystems based on the sense of security and opportunities for interaction that they provide for people. As noted by Baldwin et al. (2011), “. . . little attention has been devoted to identifying human values of nature and associated physical and mental benefits derived from landscape features and natural processes.” Further research is needed to distinguish how derived benefits from ecosystems influence not only health-related outcomes, but a full array of well-being aspects.

Although we could not identify a single composite measure of well-being to use in a predictive modeling framework for evaluating services provisioning, we did assemble the domains and indicators from these indices into a structure for a new human well-being index to develop our model. We identified 157 domains and 799 indicators among the multi-dimensional well-being measurements we reviewed. From these indices we developed a core set of well-being domains representing relevant themes common across the various measures. Four hundred forty-one of the indicators was categorized into our core set of wellbeing domains, the remaining indicators were categorized as service (economic, social, or ecosystem), capital (natural, built, human or social) or other sustainability measures (Table 2).

3. Selected core well-being domains

3.1. Health

The domain of health includes health outcome measures of personal well-being, life expectancy and mortality, and physical and mental health conditions. This domain also incorporates lifestyle behavior and healthcare, all of which influences a population’s health status. Food utilization (a part of food security) also falls into this domain because of its connection to healthy behaviors. Other outside influences such as environmental quality (e.g. clean air days, clean water, etc.) are captured through indicators of ecosystem services. Each of the indices reviewed included at least one indicator of human health. On average, 30% of the end-point

Table 1

Existing measures of well-being included in this review, the domains used in each measure and the number of metrics used to evaluate each domain (#).

Australian Unity Well-Being Index (Cummins et al., 2003)	Happy Planet Index 2.0 (Marks et al., 2006)	QOL Index for Developed Countries (Diener, 1995)
Achievements in Life (1)	Ecological Efficiency (1)	Affective Autonomy (2)
Business (1)	Happy Life (1)	Conservatism (2)
Community Connectedness (1)	Healthy Life (1)	Egalitarian Commitment (2)
Economic Situation (1)		Harmony (2)
Future Security (1)	Hong Kong QOL 2008 (Chan et al., 2005)	Hierarchy (2)
Health (1)	Economic (7)	Intellectual Autonomy (2)
How Australia Is Governed (1)	Environmental (4)	Mastery (2)
How Safe You Feel (1)	Social-Cultural (10)	
National Security (1)		Sustainable Society Index (Van de Kerk and Manuel, 2008)
Personal Relationships (1)	Human Development Index (UNDP, 1990)	Clean Environment (3)
Social Conditions (1)	Decent Standard of Living (1)	Personal Development (6)
Spirituality/Religion (1)	Knowledge (2)	Sustainable Use of Resources (3)
Standard of Living (1)	Long and Healthy Life (1)	Sustainable World (5)
State of the Environment (1)		Well-Balanced Society (5)
	Index of Child Well-Being in Europe (Bradshaw and Richardson, 2009)	
Canadian Index of Well-Being (Institute of Well-being, 2009)	Child Health (10)	The Economist Intelligence Unit's QOL Index (EIU, 2005)
Community Vitality (11)	Children's Relationships (5)	Climate and Geography (1)
Democratic Engagement (8)	Children's Subjective Well-Being (7)	Community Life (1)
Education (8)	Civic Participation (2)	Family Life (1)
Environment (14)	Education (7)	Gender Equality (1)
Healthy Populations (10)	Housing and Environment (4)	Health (1)
Leisure and Culture (8)	Material Situation (6)	Job Security (1)
Living Standard (11)	Risk and Safety (10)	Material Wellbeing (1)
Time Use (10)		Political Freedom (1)
	Nova Scotia 2008 GPI (Pannozzo et al., 2009)	Political Stability and Security (1)
Child and Youth Well-Being Index (Land et al., 2001)	Human and Social Capital (16)	
Educational Attainments (2)	Human Impact On the Environment (23)	The State of the Commonwealth Index (Watts, 2004)
Emotional/Spiritual Well-Being (3)	Living Standards (12)	Communities (7)
Family Economic Well-Being (4)	Natural Capital (30)	Economy (7)
Health (6)	Natural Capital\Human Impact	Education (4)
Place in Community (5)	On the Environment (7)	Environment (5)
Safety/Behavioral Concerns (6)	Time Use (12)	Government (3)
Social Relationships (2)	Time Use/Living Standards (7)	
		The Well-Being of Nations (Prescott-Allen, 2001)
Fordham Index of Social Health (Miringoff and Miringoff, 1999)	National Well-Being: Life Satisfaction (Vemuri and Costanza, 2006)	Culture (1)
Affordable Housing (1)	Human\Built Capital (4)	Domesticated Diversity (3)
Alcohol-Related Traffic Fatalities (1)	Natural Capital (2)	Energy and Materials (2)
Average Weekly Earnings (1)	Social Capital (1)	Freedom and Governance (4)
Child Abuse (1)		Gender Equity (4)
Child Poverty (1)	OECD Better Life Initiative (OECD, 2011a)	Global Atmosphere (2)
Drug Abuse (1)	Community (1)	Health (1)
Food Stamp Coverage (1)	Education (2)	Household Equity (1)
Gap Rich and Poor (1)	Environment (1)	Household Wealth (4)
Health Costs/65+ (1)	Governance (2)	Inland Waters (10)
Health Insurance Coverage (1)	Health (2)	Knowledge (5)
High School Dropouts (1)	Housing (2)	Land Diversity (5)
Homicides (1)	Income (2)	Land Quality (1)
Infant Mortality (1)	Jobs (2)	Local Air Quality (1)
Poverty/65+ (1)	Life Satisfaction (1)	National Wealth (4)
Teen Suicide (1)	Safety (2)	Peace and Order (4)
Unemployment (1)	Work-Life Balance (3)	Population (1)
		Resource Sectors (7)
Gallup Healthways Well-Being Index (Gallup-Healthways, 2009)	QOL 2007 in Twelve of New Zealand's Cities (Jamieson, 2007)	Sea (1)
Basic Access (13)	Built Environment (17)	Wild Diversity (2)
	Civil and Political Rights (11)	
Emotional Health (9)		Well-Being in EU Countries Multidimensional Index of Sustainability (Distaso, 2007)
Healthy Behavior (4)	Economic Development (13)	Basic Functionings (7)
Life Evaluation (2)	Economic Standard of Living (14)	Relevant Functionings (3)
Physical Health (7)	Health (27)	
Work Environment (4)	Housing (15)	
	Knowledge and Skills (11)	
Gross National Happiness (Ura, 2008)	Natural Environment (23)	
Community Vitality (16)	People (19)	
Culture (12)	Safety (24)	
Ecology (5)	Social Connectedness (19)	
Education (4)		
Good Governance (7)		
Health (7)		
Living Standards (8)		
Psychological Wellbeing (11)		
Time Use (2)		

Table 2
Categorization of indicators from existing well-being indices into a core set of well-being domains and service, capital and sustainability (other) categories. Domains represented will be included in the development of an index of well-being for the U.S.

Index	Connection to nature	Education	Health	Leisure time	Life satisfaction and happiness	Living standards	Safety and security	Social cohesion	Spiritual and cultural fulfillment	Service	Capital	Other	Total
Australian Unity Well-Being Index (AUI)			1		1	1	4	2	1	3	1		14
Canadian Index of Well-Being (CIW)		8	8	9		6	4	11	4	23	1	6	80
Child and Youth Well-Being Index (CYI)		6	11			2	2	2	2	3			28
Fordham Index of Social Health (FSH)		1	3			4	3			5			16
Gallup Healthways Well-Being Index (GHI)		1	18		3	2	2	2		11			39
Gross National Happiness (GNH)		8	10	3	1	7	3	14	6	11		9	72
Happy Planet Index 2.0 (HPI)			1		1							1	3
Hong Kong QOL 2008 (HKQ)		2	3		1	3	1			10		1	21
Human Development Index (HDI)		2	1							1			4
Index of Child Well-Being in Europe (CWE)		8	17		1	5	4	11		5			51
National Well-Being: Life Satisfaction (NWB)		2	1							4			7
Nova Scotia 2008 GPI (NSI)		6	7	7		8	6	5		48	3	17	107
OECD Better Life Initiative (BLI)		2	2	2	1	4	2	1		6			20
QOL 2007 in Twelve of New Zealand's Cities (NZC)		10	20	4	3	25	24	17	2	61	1	26	193
QOL Index for Developed Countries (DCI)		2	1		1	3	1			6			14
Sustainable Society Index (SSI)		1	1			2				12	2	4	22
The Economist Intelligence Unit's QOL Index (EIU)			1				1	2		4		1	9
The State of the Commonwealth Index (SCI)		4	2			3	1	1		14	1		26
The Well-Being of Nations (WBN)		3	2			4	3		1	36	7	7	63
Well-Being in EU Countries		1	2							7			10
Multidimensional Index of Sustainability (EUI)													
Total	–	67	112	25	13	79	61	68	16	270	16	72	799

indicators in each index fell into the health domain. Life expectancy and mortality were the most frequently used indicators. Most of the indices included measures of health-related behaviors and self-reported health.

The connections between economic services and human health are so numerous and complex that an entire sub-discipline of economics, known as health economics, has emerged. Economic assessments of health-related interventions are critical to decision makers because expenditure on health care in the United States has outpaced the general rate of inflation (Meltzer, 2001). Social services are also strongly tied to human health. Many large organizations within the U.S. government were formed to protect and enhance the health of the U.S. population, and several well-known private organizations such as the American Red Cross, United Way of America, and Ronald McDonald House Charities provide health-related services to populations in need.

The impact of environmental quality and condition on human health is well known, yet the connection between ecosystem services and human health and development is a relatively new field of study. McMichael et al. (2003) point out that climate change is known to have an adverse affect on human health and that an estimated 83% of medicinal goods have yet to be discovered and used for human benefit from tropical vegetation, much of which could be lost forever if biodiversity continues to decline. Ecosystem condition also has direct impacts on human health resulting from bacterial contamination, air pollution, and toxic algal blooms (Cox et al., 2003). Access to nature, even if only through a window view, provides restorative experiences that can improve psychological and physiological health (Van Den Berg et al., 2007).

Greenspace and connection to nature have been linked to healthy physical, cognitive, and behavioral development, especially in children and youth. For instance, sensory stimulation promoted positive healthy-related behaviors by affecting interpersonal processes among a group working in a community garden (Hale et al., 2011). Children and youth living in greener neighborhoods had lower BMI after 2 years, presumably due to increased physical activity or time spent outdoors (Bell et al., 2008). Children also see improvements in motor fitness, balance, and coordination when provided with a natural landscape for play (Fjortoft, 2004). Lifestyle is responsible for the bulk of the current avoidable disease burden, making the impact of ecosystem services on healthy behaviors that much more important (De Hollander and Staatsen, 2003).

3.2. Social cohesion

The ties that bind humans together in society having a large bearing on our personal well-being and the well-being of our community (Putnam, 2000, Smith, 2003). A social network propagates opportunities to enhance the quality of life to all of its members, and creates a safety net for difficult times. A cohesive community allows open discussion and resolution of difficult problems, and gives its members a sense of identity (Jeannotte et al., 2002). Social participation of all concerned citizens is essential to obtaining environmental well-being (Mann, 1992). Sixty-eight indicators from 11 indices reviewed were categorized as measures of social cohesion. The *Canadian Index of Well-being*, *Gross National Happiness* index, and *The Economist Intelligence Unit's QOL Index* contained the highest percentage of indicators in this domain. The indicators of social cohesion varied greatly, with the most common indicator being volunteering rates. Measures of the health of one's social network typically revolved around qualitative assessments of existing relationships and quantitative assessments of the size of the network. Feelings and behaviors associated with trust and reciprocity are often used as a proxy for community cohesion. Divorce rates, migration patterns, family demographics, and charitable

contributions were some of the more objective measures used to measure cohesiveness.

Social services can establish social norms that promote cohesion, repair and strengthen family cohesion, and provide safe, equitable working environments which foster healthy coworker relationship development. Economic services impact social cohesion by creating equitable wages and redistributing wealth, thereby relieving tensions between different social-economic classes (Rupasingha et al., 2006), and they allow businesses to generate excess revenue to be given back to the community. Greenspace and access to nature promote pro-social behavior and help mitigate some of the negative antisocial behaviors associated with crowding and urbanization (Kuo and Sullivan, 2001, Kuo, 2010). Natural spaces within communities afford people opportunities to interact with others beyond their own family dynamics through proximate open areas reserved for recreational and cultural activities, such as festivals and picnics. A healthy natural environment also helps to provide a sense of community by enhancing feelings of pride and a stronger sense of kinship among its citizens who share the common goal of making their community a better place to live (EPA, 1997).

3.3. Education

The domain of education is defined as the outcomes derived from the formal and informal transfer of knowledge and skills and is measured using standardized test scores, literacy rates, and educational attainment and participation. Sixty-seven indicators, accounting for 15% of the endpoint measures identified in our review, were categorized in the domain of education. Only three indices (*Australian Unity Well-Being Index*, *Happy Planet Index 2.0*, *The Economist Intelligence Unit's QOL Index*) altogether lacked indicators of education, while education-related indicators dominated the *Human Development Index* and the *National Well-Being: Life Satisfaction* index. Education has been referred to as a basic capability leading to the expansion of other capabilities and is fundamental to well-being (Terzi, 2004). Educational progress and benefits influence other well-being domains and may be measured at either the individual level by economic returns or by subjective feelings of achievement and accomplishment, or at a societal level by creating a skilled workforce with enhanced worker productivity, lower crime rates, and greater civic participation (Guhn et al., 2010; Hill et al., 2005).

Economic and social services provide funding and other programs that influence the access to and opportunities for education. Educational services provide programs aimed at reaching more students, especially those with disabilities or other special circumstances, and by hiring adequate and qualified teachers. Community and faith-based initiatives may also act in this manner to reach additional children and families. Communication through public broadcasting and public service announcements helps educate the public about various issues (e.g. public health issues). Financial assistance in the form of grants, scholarships, and student loans is also essential to allow opportunities for post-secondary education.

Ecosystems provide a plethora of learning opportunities at many levels of education. Some areas may be designated as public learning centers and accessible to all ages, while post-secondary educational institutions may use natural areas for teaching and scientific research (EPA, 1997). Environment-based education programs and school ground greening in elementary and secondary schools have shown several positive effects on the mental health and brain development in early and middle childhood. These benefits include improved standardized test scores and problem-solving skills, decreased symptoms of attention deficit disorder, and enhanced cooperation and interpersonal skills, all of which lead to

a better educational experience and improved well-being (Guhn et al., 2010; Louv, 2005; Lieberman and Hoody, 1998).

Ecosystem research is also integral to innovation and the progression of society. By studying the function and uses of organisms, we are able to discover untapped sources of pharmaceuticals, crops, and other goods and also transfer that knowledge into art, other scientific fields, and practical affairs (Wilson, 1993). Local environmental knowledge is also important in providing historical accounts of an area, which contribute to scientific research and environmental management, but also to various cultural aspects of the area as knowledge is passed down through multiple generations (Huntington, 2000). Continual research on ecosystems is crucial for understanding how ecosystems provide services that effect human well-being, as well as understanding how our actions affect the provisioning of these services.

3.4. Safety and security

Based on Maslow's hierarchy of basic human needs, once physical needs are relatively satisfied safety needs take precedence. Fifteen of the indices reviewed included metrics we categorized as safety and security domain measures. Personal security can be linked to unemployment, poverty, education level and social cohesion, and is most often evaluated using crime rates, number of accident-related injuries and deaths, and perceived safety. In basic terms, safety and security can be described as freedom from harm (physical security-personal and national), but is also described by measures related to financial security.

Economic security is one of the four domains of the Index of Economic Well-being which is utilized in the *Canadian Index of Well-being*, *Nova Scotia GPI* and the *OECD Better Life Initiative* (Osberg and Sharpe, 2009; Pannozzo et al., 2009; Sharpe and Arsenault, 2009). Economic security is evaluated in the event of unemployment, sickness, widowhood, old age and disability. These measures can be linked to economic services of employment and income and heavily associated with social nets provided through the provisioning of social services, particularly financial assistance and healthcare. Our sense of safety and security can be altered in the wake of technological and natural disasters due to degradation of ecosystems, economic loss, and increased reliance on social safety nets and recovery services. From the ecosystem services perspective, clean water and air, sufficient food production and natural hazard protection significantly contribute to our sense of safety and security through direct relationships to our health via exposure to pathogens and contaminants, food supply and prevention of loss of life and property (MEA, 2005). Additionally, there is a comfort derived from knowing that we are not on the brink of environmental problems and that natural system will be conserved for future generations (Higginbotham et al., 2007).

The domain of safety and security is frequently evaluated using violent crime and property crime rates combined with measures of perceived neighborhood safety. Green spaces in urban areas have been linked to a reduction in neighborhood crime, especially in inner city neighborhoods (Kuo and Sullivan, 2001). Urban green spaces provide opportunities for simultaneous users and increased throughput which in combination deter criminal behavior; however, densely vegetated areas often evoke feelings of insecurity (Kuo, 2010; Kuo and Sullivan, 2001). In some cases, natural areas appreciated for aesthetic and therapeutic value and recreational opportunities may also be perceived by some as "scary" places, concealing criminal activities or harboring dangerous animals, poisonous plants and vector borne disease (Louv, 2005; Milligan and Bingley, 2007). In reference to accident-related injuries, more specifically traffic accidents, there are opposing views on the role of roadway vegetation. Roadside aesthetic appeal has been reported to positively affect driver behavior by promoting a calming effect

and reducing speeding and driver fatigue (Cackowski and Nasar, 2003). Conversely, traffic engineers and city planners purport that roadside vegetation introduces collision hazards, reduces traffic visibility and distracts drivers (Wilde, 2010). Similarly, public perceptions may present conflicting valuations of ecosystems such as wetlands, which are valued for species diversity, habitat and recreational areas, but also depreciated because of associated vector borne diseases such as West Nile virus (Barbier et al., 1997). However, approaches such as developing measures to protect amphibians in wetland pools can help control mosquito production potentially minimizing disease risk to humans (Rubbo et al., 2011). Unfortunately such knowledge is often limited to the scientific community.

Due to the multitude of conflicting perceptions, the fear of nature and lack of public knowledge regarding ecosystem goods and services benefits, the evaluation of the contribution of ecosystems to safety and security is not as clear cut as the influence of economic and social drivers. However, clarifying these relationships through education and inclusion of public perception and preferences could help mitigate these differences towards a better understanding of the linkages between ecosystems and the domains of well-being. A common understanding of nature's benefits is vital to sustainable well-being.

3.5. Living standards

In the simplest of terms, living standards may be best described as "the physical circumstances in which people live, the goods and services they are able to consume and the economic resources to which they have access" (New Zealand Economic Social Report, 2010). Living standard indicators tend to be largely economic in nature, characterized by demography and geography. Fifteen of the indices reviewed included at least one indicator categorized into the living standards domain. Seven of the existing indices used living standards measures as the primary source for the development of their index. Income level was the most dominate class of metrics used for evaluating standard of living followed by living conditions, e.g. housing status, household crowding (rooms per person) and state of housing repair. Home ownership, household assets, and other measures of material affluence were used to evaluate wealth. Only the *Australian Unity Well-being Index*, *Gallup Healthways Well-being Index* and *Gross National Happiness* index included subjective measures as part of the living standards domain.

Economic and social services aim to improve the living standards of a population. Economic services provide a means to accumulate and distribute wealth while many social services help improve living conditions among the most impoverished within the community. Poverty metrics (e.g. income- and housing-related) figure prominently in living standard assessments because there is a close relationship between standards of living and attainment of basic human needs. However, wealth disparity alone cannot fully account for standards of living. Current research suggests that conceptualizing basic human needs in light of multi-dimensional well-being may provide a more comprehensive picture relative to living standards (Sen, 1993; Sumner, 2004; Waglé, 2008). For example, indices that exclude time use measures may be missing non-market activities that may enhance standards of living without significantly contributing to household income (Folbre, 2009). Further, the perception of living standards is often an overlooked influence on a population's overall well-being.

Ecosystem services may greatly influence living standards both monetarily and non-monetarily. Coastal and Great Lake ecosystems, for example, create approximately 100 million jobs nationwide (National Ocean Economics Program 2009). Ecosystems such as wetlands or grasslands provide regulating services that may reduce infrastructure cost by using existing natural

capacity for increasing the availability of clean and safe drinking and recreational water. Urban greenspace helps mitigate environmentally borne health-related illness such as asthma thus reducing healthcare-related costs and stress. Easy access to natural space provides opportunities for culturally fulfilling, quality recreational activities for those populations who are most likely to have the least amount of leisure-time available.

3.6. Leisure time

Leisure time is time that individuals have to voluntarily engage in pleasurable activities when they are free from the demands of work or other responsibilities. It is commonly deemed as necessary for basic survival, and has increasingly been referred to as a domain of the “good life” (Smale et al., 2010); however, leisure time was one of the lesser cited domains among the indices we reviewed. Only five of the indices reviewed included measures of leisure time. The *Canadian Index of Well-being* and *National Well-being: Life Satisfaction* index suggest metrics of the amount of time spent on specific leisure activities, types of activities frequency of participation, and expenditures on leisure activities. Measures of work hours and continuous sleep time (*Gross National Happiness* time use domain) can be used as surrogate measures indicating the amount of time available for leisure activities. The *OECD's Better Life Initiative* includes a measure of time dedicated to leisure and personal care to describe work-life balance. Enjoyable activities may also act as “restorers” that facilitate the individual's recovery from stress as the result of positive social interactions or relaxation that lead to increased positive emotions (Pressman et al., 2009).

Participation in leisure time activities has been positively linked to both physical and mental health measures (Krueger et al., 2009; Williams and Patterson, 2008). Leisure time also provides for psychological detachment from work which in turn promotes well-being and productivity (Sonnentag and Binnewies, 2010). Leisure time activities also provide opportunities for social interactions through group participation (i.e., clubs, sports, religious organizations) and expand the size of social networks, enhancing social cohesion. Higher income has been positively associated with increased leisure time as it relates to more disposable income; however, in the U.S. the cost of the loss of leisure time due to increased work hours has continued to rise since the 1950s (Talberth et al., 2007).

Specific activities individuals engage in can be linked to access and exposure to nature and greenspace. According to Korpela and Kinnunen (2010), time spent in interaction with nature is significantly correlated to both life satisfaction and relaxation, contributors to our SWB and health. Among a variety of leisure time activities evaluated, exercise, spending free time outdoors and interacting with nature were the most effective activities for recovery from work stress (Korpela and Kinnunen, 2010). These activities are closely tied to recreational opportunities and aesthetics, biodiversity, usable water (swimmable, fishable), and clean air. The U.S. downward trend in the amount free time afforded to individuals places increased value on the amount of time available outside work. The potential impact of outdoor activities and interactions with nature on our well-being exemplifies the contribution of ecosystem goods and services that support these leisure activities.

3.7. Spiritual and cultural fulfillment

This domain captures metrics that measure opportunities that afford people and communities access to fulfilling their spiritual and cultural needs. Of the indices reviewed, six describe indicators that measure attributes of culture and spirituality. A mix of metrics is represented in this domain, encapsulating both participation

and opportunity measures. Indicators such as religious or festival attendance specifically describe access, while other measures are multi-faceted and may represent cultural interests, cultural identity, and/or connection to nature (i.e., visits to national parks). Spiritual and cultural indicators encompass values-driven metrics that examine the concepts of the “self” that centers around vital interconnections with others and the environment (Centre for Rural and Remote Mental Health, 2009).

While there are many variations of the specific definition, few would argue the important role of spirituality and culture within populations. Spiritual and cultural values are in many ways integral to vital communities yet are rarely considered in most well-being indices evaluated. Investment in houses of worship, museums, cultural centers, and other similar gathering places offer educational opportunities to help mitigate inequities typical of cultural or spiritual exclusion. Faith- and community-based activities such as festivals, concerts, arts and crafts shows, etc. further strengthen social cohesion by preserving cultural and spiritual heritage. Moreover, it is the environmental “culture” that is often the harmonizing factor that supports community vitality when obvious economic disparity would otherwise cause discord (“A Tale of Two Aspens” 2011).

Cultural ecosystem services represent the “non material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences” (MEA, 2005, p. 40). For many populations, culture and spirituality are strongly connected with the environment. Swan and Raphael (1995) noted that Aboriginal Australians holistically view “health” as harmonized, inter-relating factors that include spiritual, environmental, ideological as well as mental and physical aspects that, collectively, are identified as “cultural well-being”. The social, sacred, and cultural aspects of ecosystems significantly contribute to Native American well-being, but are often overlooked in qualitative assessments. Native Americans seek cultural and spiritual fulfillment by communing with nature, praying and meditating, fishing and hunting, collecting herbs, and conducting vision quests or other ceremonies (Burger, 2011).

The interwoven relationship between humans and the landscape is manifested in cultural diversity and heritage, educational values and ecological knowledge, social relations and sense of place (MEA, 2005; Rössler, 2006; Schaich et al., 2010). The tangible and intangible heritage associated with the human nature interface is tightly coupled with people's involvement in environmental conservation (Philips, 1998). Thus it follows that cultural and spiritual fulfillment is influence by our connection to natural systems and opportunity to identify with our heritage through visits to natural historical sites, national parks and celebrations revolving around cultural landscapes and nature's bounty.

3.8. Life satisfaction and happiness

Life satisfaction and happiness is defined as the contentment with our life and is measured by self-reported happiness and satisfaction with life as a whole. Only 3% of the endpoint measures were identified for the domain of life satisfaction and happiness. The *Happy Planet Index 2.0* attributed 50% of its indicators to this domain. There are many factors in a person's life that may affect their SWB (e.g. happiness and life satisfaction), including education, marital status, age, and income, while happiness and life satisfaction may affect health and social outcomes (Bonini, 2008; Ng, 2008). It also goes to say that even when someone has “everything they ever wanted” that he or she may still feel that they are not living a fulfilled life or one with meaning and purpose.

Economic drivers have an effect on life satisfaction and happiness, not only in the sense of personal wealth or financial security, but an overall better quality of life by funding other services

necessary to society's needs. Using the GDP as a measure of well-being, however, is increasingly questioned (Costanza et al., 2009). Robert F. Kennedy had also noted the shortfalls of the GDP stating that "...it measures everything, in short, except that which makes life worthwhile." Our personal desire to make more and more money is likely driven by our constant comparison to friends, neighbors, and colleagues and plays a role in determining our well-being (D'Ambrosio Frick, 2007). There is also evidence that as societies become wealthier (more so after basic needs are met), they experience increased mental and social problems, and life satisfaction hits a plateau (Diener and Seligman, 2004).

Social services act to increase life satisfaction and happiness mainly by increasing social cohesion, social networks, and health. These services may be largely affected by governmental policies, programs, and funding; however, they may also originate from individual and community involvement. For instance, community and faith-based initiatives span many social services and fill in the gaps left over by government policies or programs in order to reach underrepresented areas of the community.

Healthy and diverse natural environments are thought to be essential for humans to lead satisfying and fulfilling lives, but our increasing disconnection from nature is resulting in a downward spiral of unhappy people and an unhealthy environment (Kellert, 1997; Nisbet et al., 2011). The condition of an ecosystem can influence life satisfaction and happiness directly and indirectly through various social and cultural aspects by affecting sense of place, degree of community involvement, trust, and participation in recreational activities (Cox et al., 2003; Higginbotham et al., 2007). Additionally, life satisfaction is significantly affected by utility and monetary losses from natural disasters, of which can be minimized by the ecosystem service of natural hazard protection (Luechinger and Raschky, 2009).

It has been shown that people who strive to protect ecosystems through activism and behavior have a higher "nature-relatedness" (NR), or connection to nature, which is positively correlated with personal growth, a sense of purpose in life, and an improved overall SWB (Nisbet et al., 2009, 2011). Our NR is mostly achieved through access to and experience in nature. It's no surprise that the most popular tourist destinations are widely dependent on the natural beauty of an area—whether it is a forest, beach, or mountains—and is where people go to obtain a sense of inspiration and renewal (Cox et al., 2003; EPA, 1997).

3.9. Connection to nature

Humans' connection with nature is a subjective trait most easily explained by the biophilia hypothesis. Biophilia is a term coined by prominent evolutionary biologist and entomologist, Edward O. Wilson, who defined it as the "innately emotional affiliation of human beings to other living organisms" and hypothesized that this psychological, and possibly genetic, phenomena arose due to humans' long time interaction with the natural environment (Wilson, 1984, 1993). Measures of biophilia, topophilia, appreciation of nature, and solastalgia reflect the state of human well-being (Higginbotham et al., 2007), whereas the measurable output from ecosystems and the capacity of ecosystems to sustain ecosystem services (Deutsch et al., 2003; Prescott-Allen, 2001; Vemuri and Costanza, 2006; Sutton and Costanza, 2002) are indicators of natural capital and services provisioning. Biophilia is most evident by the popularity of zoos and outdoor activities and in people who have non-economic motivations for the protection of natural areas and biodiversity, such as positive experiences of an area, solastalgia, and having affection or sympathy for non-human species (Serpell, 2004; Martin-Lopez et al., 2007; Chawla, 2006; Wilson, 1993; Nisbet et al., 2011).

Our connection to nature is also evident in other domains of well-being such as spiritual and cultural fulfillment, education, health, and leisure time. Humans, however, are experiencing an increasing disconnection with nature through urban development and technology—especially noted in children as the "nature-deficit disorder" and coincides with rising trends in obesity, attention deficit disorder, and depression (Wilson, 1993; Kellert, 2005; Louv, 2005). An attempt to correct this growing disconnection and to incorporate the health of the environment in land use planning is through "biophilic design", which aims to enhance human physical health, psychological benefits, and productivity by fostering a human-nature connection (Baldwin et al., 2011). Although our detachment with nature will never completely rid us of desire to associate with nature, it can weaken our appreciation for nature and decrease our well-being (Kellert, 1997).

The human–nature connection is largely affected by biodiversity and amplified by access to nature and exposure to diverse, healthy ecosystems (Wilson, 1993). NR, similar to biophilia has been used to quantify our connection to nature (Nisbet et al., 2011). Natural areas and green spaces are needed for humans to experience nature and increase NR, which is most often accomplished through the ecosystem goods of recreation and aesthetics. The total area of these spaces directly affects the availability and diversity of recreational and aesthetic opportunities, and the health of the ecosystem and its ability to provide other services such as water and air quality regulation (Pongsiri and Roman, 2007; MEA, 2005; EPA, 1997). Additionally, due to the interconnectedness of plants and animals occupying these areas, biodiversity is especially important for the functioning of the ecosystem and of humans psychologically (Chavas, 2009; MEA, 2005; Nisbet et al., 2011; Kellert, 1997).

Economic and social services also have significant direct and indirect effects on the connection to nature domain. For example, economic programs and funding can increase or decrease natural areas, either by putting aside more areas or decreasing those areas through capital investment (e.g. new infrastructure, mining/extraction activities). Additionally, social services such as activism, community and faith-based initiatives, justice (e.g. environmental justice), and public works can affect policies that support ecosystems, or can possibly be used as indirect measures of our connection to nature.

4. Well-being and sustainability

In our consideration of the interdependence of humans and ecosystems, we cannot ignore the social, economic and political aspects that affect the condition of both. This notion follows Wright's (2001) concept that all living things are linked in a fundamental web of interdependence and that our ultimate survival hinges upon finding solutions to social, political, and economic issues that are *non-zero-sum* (Tov and Diener, 2009). Research approaches linking ecosystem services to human health, welfare, and economic valuation exemplify the three interdependent pillars of sustainability—environment, society, and economy (Koehler and Hecht, 2006) and must be anchored in broad-based multidisciplinary research that encompasses complex socioeconomic issues in relation to environmental changes (Cabrera et al., 2008; Hadorn et al., 2006; Bradshaw and Bekoff, 2001; Lubchenco, 1998).

Increasingly, communities across the U.S. are examining the management of growth through sustainable development. Some integrated indices such as Prescott-Allen's the *Well-being of Nations* (2001) present sustainability progress by evaluating levels of human development and ecosystem well-being. Many similar indices focus on the point where human well-being and environmental conditions intersect rather than how they are related—a critical component for emphasizing the symbiotic relationship

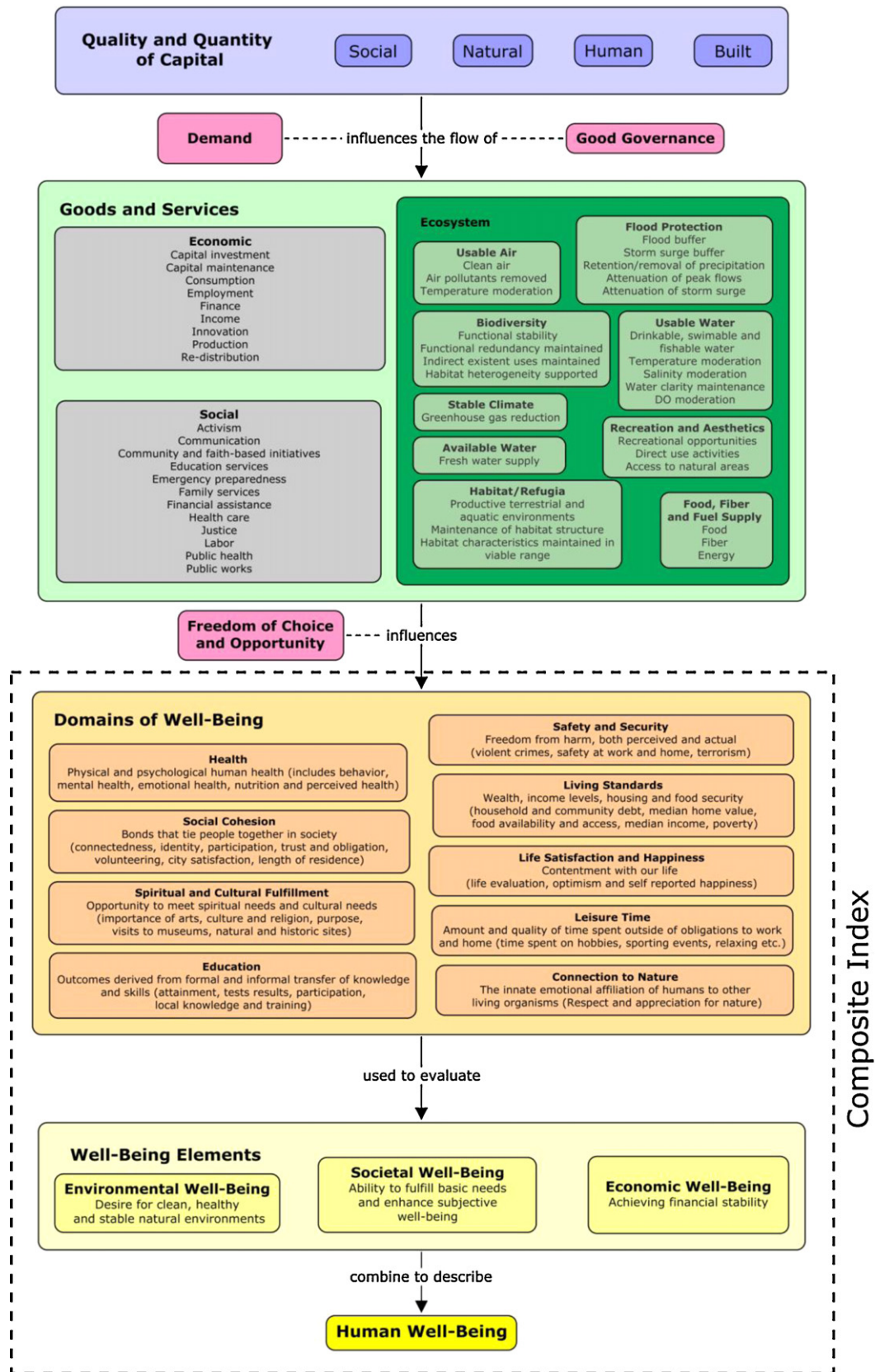


Fig. 1. Conceptualization of proposed modeling structure for evaluating the influence of service flows on human well-being using a composite human well-being index as the endpoint.

between nature and humans. Still other sustainability indicators strictly vilify human activity in the natural environment instead of highlighting the impact that changes in the provisioning of ecosystem services may have on humans. It is important to recognize human well-being as an endpoint indicator that describes the performance of sustainable decisions. Since people are the beneficiaries of sustainable solutions, it is essential that metrics reflect the dependence of humans on ecosystems—services provided that contribute to economic well-being, the ability to meet basic needs, and life satisfaction—in order to progress sustainably.

5. Proposed modeling structure

The majority of indicators in the indices reviewed here were delegated to the services category (Table 2). The services identified indicators describe the quantity and quality of ecosystems, economic drivers, and social inputs. These types of measures will not be directly used in our well-being index. Rather, these indicators help quantify the delivery of services which is the basis of our modeling efforts to predict well-being endpoints. To better understand the relationship between ecosystem provisioning and human well-being, we must integrate service flow values from natural, social, human and built capitals. The quality and quantity of capital stocks drives the availability of services which only become goods and services once demanded. Good governance, the ability to efficiently deliver resources to people influences the goods and services provided. Our predictive model will consist of three integrated modules—economic services module, social services module and an ecosystem services module. Fig. 1 highlights the core ecosystem goods and services we will use in the overall model. This paper has described the relationships between these services and the domains of well-being that will be used to develop the index. In order to benefit from the goods and services provided by ecosystems, the opportunity must exist for individual, communities and nations to benefit from them. Additionally, these opportunities must be made available to future generations in order for us to become a sustainable society.

With the exception of the connection to nature domain, the domains suggested for our index structure were common among the indices we reviewed, however, the domains presented here most closely reflect the domain structure used in the *Canadian Well-being Index* and the *OECD Better Life Initiative* index. Indicators used to develop these domains for our index will differ from those used in these two indices since we are only considering “ends” measures for our well-being endpoint measure in a predictive modeling framework. Our next steps will focus on indicator selection and composite index methodologies. The indicators selected to describe the well-being domains will be transparent to cultures, time and spatial scales to allow us to evaluate well-being at local, regional and national scales. We will be developing an approach to use relative importance values to assign weights to domains relationships for the composite measure of well-being for the U.S.

6. Concluding remarks

Many obstacles exist in developing comparable measures of human well-being—lack of consistently available data, transparency of performance of indicators and domains and cultural differences in the perception of well-being. We are aware that even within disciplines, the aggregation of indicators to create an index for evaluating well-being is highly contentious and that many researchers argue that summary indices have no value as tools in policy forums (Booyesen, 2002; Saltelli, 2007). Additionally, lack of scientific robustness has rendered many sustainability indices inadequate in the policy arena (Böhringer and Jochem, 2007).

Perhaps for these reasons, many well-being measures have been delegated to specific areas of economic and social policy in isolation. However, composite indices represent an aggregate of the most widely accepted measurements within a particular discipline (i.e., sociology, economics, ecology, health) and the individual indicators used to develop the composite measure are based on quantitative values, generally recognized qualitative assessments, and sound methodologies. The ultimate goal of this research is to create a balanced index of well-being for the U.S. that will illustrate the importance of ecosystem services in context of social and economic drivers which adequately emphasizes the degree to which environmental factors influence well-being endpoints.

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