Completing the Picture: The Challenges of Bringing "Consumption" into the Population–Environment Equation[1]

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The issue of environmentally significant consumption is closely linked to population–environment relationships, but with some exceptions the two literatures have proceeded along separate tracks. We explore three consumption–environment research agendas: household–level consumption; ecological footprints and material flow accounting; and values, attitudes, behaviors and lifestyles. In each of these we note areas of overlap with the population–environment literature, and ways in which the population–environment literature might benefit or borrow from conceptual or methodological approaches in the consumption–environment literature. We also propose ways in which consumption research might be integrated into the largest (in terms of funding) of the population–environment research agendas, land-use and land-cover change research. In the concluding section we present a conceptual framework for understanding the population–environment literature that incorporates production and consumption into the model, and we propose some population–consumption–environment (PCE) research areas to which the population-environment research community could make significant contributions.

KEYWORDS: environmentally significant consumption; demography and the environment.

INTRODUCTION

As scientists, activists, and policy makers have struggled with how best to understand the relationship between population and environment, they have come up against different paradigms for conceptualizing the ''problems'' or the relationship. Ever since the 1960s when Hardin's and Carson's essays galvanized the environmental movement, created justifications for new disciplines in the social and biological sciences, and established new agencies and policies, the primary focus has been upon models and measures of resource consumption at the point of production (Princen, 2001).[2] Consequently, producers were to blame for consuming resources inefficiently or violating environmental regulations to the detriment of human health and well-being. Although researchers discussed the relative roles of population, consumption and production, government policies tended to focus upon production processes because the mechanisms for improving efficiency and decreasing emissions seemed more apparent and more likely to cause a dramatic improvement in environmental conditions. Targeting the industrial sector via pollution and waste reduction policies was, in all likelihood, also perceived as less daunting and more effective than trying to change the behavior of millions of individual consumers. And indeed, the outcome of concerted government regulation and tax policies has yielded relatively dramatic improvements in energy efficiency among producers in the United States (Smil, 2003). Nevertheless, in the last decade all of the energy gains in the production sector have been offset by changes in consumer preferences (e.g., larger automobiles and houses). The result is that the United States has the same per capita energy consumption as a decade ago (Smil, 2003).

Initially identified as the ''A'' in the IPAT equation (Environmental Impact = Population × Affluence × Technology) (Dietz & Rosa, 1994; Ehrlich & Holdren, 1971), consumption has garnered increasing attention in recent years (Brown et al., 1992; Durning, 1992; Myers, 1997). Research on *environmentally significant* consumption, defined as consumption of materials or energy in such as way as they are less available for future use or have harmful effects biophysical and human systems (Stern, 1997), has similarly grown since the mid-1990s (see, e.g., Stern, Dietz, Ruttan, Socolow, & Sweeney, 1997; York et al., 2003; and many references cited elsewhere in this paper). Much of this research falls outside the ''core'' population–environment literature, a literature largely defined by the contributions of demographers and to a lesser extent economists and geographers.[3] Consumption–environment research, by contrast, is being carried out by researchers coming from a broad range of disciplines such as economics, ecology, industrial engineering, psychology and anthropology.

There are two major reasons why the population–environment and consumption–environment literatures have taken separate trajectories. First, the two research agendas have focused on different types of questions. During much of the last decade, the population–environment literature has primarily focused upon providing evidence for linking demographic characteristics and processes to environmental outcomes or conditions. Demonstrating this linkage has been very successfully accomplished through spatial modeling approaches and locating humans and human activity next to or within environmental conditions or contexts. Central questions in this literature are: How do basic fundamental demographic processes, like fertility, mortality, population growth rates, and migration affect environmental outcomes? What are the reciprocal relationships and interdependencies among demographic and environmental variables? How do intervening conditions affect the population–environment relationship? The consumption and environment literature asks a set of related, but quite different questions. Which human activities are the most significantly disruptive to the environment? Who is most responsible for these destructive outcomes? What causes environmentally disruptive outcomes? And, how are environmentally disruptive activities changed?

The second reason that the literatures have progressed along separate paths is that the population–environment research has largely focused on developing countries whereas the consumption–environment research has focused heavily on developed countries. Although not a perfect measure, a quick count of the Population–Environment Research Network eLibrary[4] holdings by continent reveals that three-quarters of the citations relate to developing countries and only one-quarter to developed countries. A related difference between the two literatures is that population–environment research has mostly focused on micro-level studies in rural subsistence economies, whereas the consumption–environment agenda typically addresses consumption patterns among largely urban-based consumer societies in which it is assumed that most of the resources consumed are imported from outside the immediate area in which the consumption is taking place.[5]

As we just argued, the population–environment literature developed coincidentally with the literature on environmentally significant consumption and a significant cross-fertilization of ideas has not yet occurred. Although most population–environment researchers give a nod to the IPAT model, which is the most important bridge between population–environment and consumption–environment literatures, rarely is the model explicitly tested and subsequently refined (exceptions include Dietz & Rosa, 1997). In this paper, we propose a small step forward towards the integration of ideas from each area.

Our small step forward identifies and describes three different social science research agendas that systematically explore consumption. We describe their contributions and limitations. We then describe a major line of inquiry in the population–environment literature—land-use and land-cover change (LUCC) research—and we propose how it might be usefully situated within a population, consumption, and environment (PCE) framework. Finally, we present a conceptual framework for understanding the population–environment literature that incorporates production and consumption into the model, and we propose some PCE research areas to which the population–environment research community could make significant contributions.

THREE SOCIAL SCIENCE RESEARCH AGENDAS ABOUT CONSUMPTION

Here we briefly assess three areas of consumption–environment research. In the first, we describe how social scientists have shifted their attention from nationally aggregated consumption statistics to household-level analyses of several important consumption domains. In another line of research, biological, physical and social scientists have developed indices to measure ecological footprints and material flows arising from consumption and shown how these indices are valid and predictive. Finally, in a third line of research social scientists have begun to explore how values and attitudes shape consumption behavior, how consumption may in turn shape attitudes towards sustainable consumption, and how values and attitudes shape lifestyle choices.

Households as Units of Analysis

Per capita energy consumption has been one of the most commonly used metrics of consumption for a number of reasons. It is easy to measure (relative to materials consumption), it has easily convertible units (joules, calories, watts, etc.), and each unit of energy consumption is environmentally meaningful (in terms of pollutants or greenhouse gas emissions). Yet understanding of national-level per capita consumption of any resource offers limited insight for policy action, since variations within populations can be great, and they are significantly influenced by household characteristics. O'Neill, MacKeller, and Lutz (2001), working in the area of population and climate change, found that changes in the number of households are a better predictor of greenhouse gas emissions than overall population growth.[6] This is because later ages at marriage, divorce, fertility declines and population aging have resulted in smaller household size, whereas the actual energy needs per household do not diminish in proportion to the size of the household (O'Neill and Chen, 2002). A significant reason for this is that space heating/cooling needs and the number of appliances is only loosely related to the number of inhabitants in a dwelling. In fact, research in California found that energy consumption for a one person household was only half that of four and five person households (Lutzenhiser, 1997).

Using households as a unit of analysis has other advantages. Although households are not the only units of final consumption in society—governments and business investments also consume products (see Figure 1)—we can say that these other units of consumption, to a greater or lesser degree, support the wellbeing of the population, and that the population itself is composed of economically and socially integrated units called households. Thus, households are the end-users or beneficiaries of production processes. Furthermore, apart from a small minority of households, household members generally pool economic resources and act collectively with regard to consumption decision-making.[7] Finally, households are often the holders of capital and make savings decisions that affect the consumption of resources. Thus, it can be said that households represent a useful scale for consumption–environment studies.[8]

Spangenberg and Lorek (2002) have identified three household consumption "clusters" that together account for nearly 70% of an economy's material extraction and energy consumption, and more than 90% of land use. These are construction and housing, food and nutrition, and transport and mobility. Bin and Dowlatabadi (in press) similarly attribute significant portions of final consumption to households. Using a consumer lifestyle approach (CLA), they estimate that when taking into account both direct and indirect demands for energy by households, more than 80% of energy used and CO_2 emitted in the US are a consequence of consumer demand. This is double the previous estimates, which generally only accounted for the direct energy demands for home energy and personal travel.

Trends in housing-related energy consumption, which are driven by heating technologies, house area, insulation, and appliance ownership, appear to be saturating (Schipper, 1997), yet they currently account for an estimated 49% of household energy consumption (Langhelle, 2001). Research on housing-related energy use in California demonstrated that both social (lifecycle stage, wealth, ethnicity) and technical (age, type, and

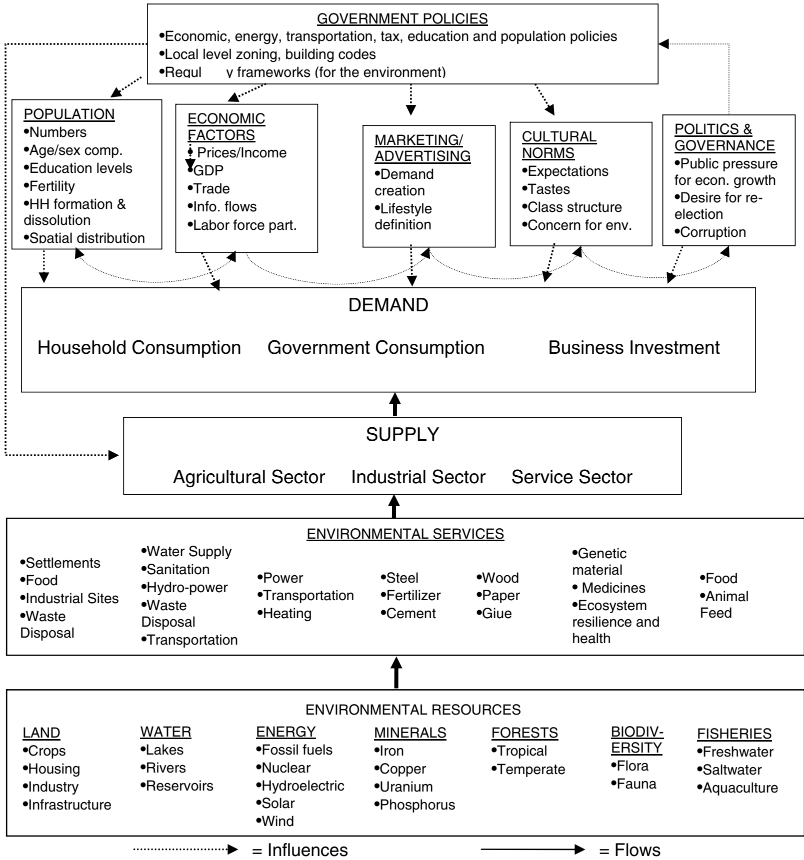

FIGURE 1. Production and consumption dynamics as they relate to population and environment.

This figure provides a schematic of the consumption chain and specifies the influences on household consumption that have been identified in the literature. These major influences are represented by the set of boxes with dashed lines that influence demand. Although the diagram shows the supply being determined by the demand, note that this does not represent endorsement of the notion that supply is strictly determined by consumer sovereignty. We acknowledge the important consumption demand represented by government and business investment, and the many influences upon consumer demand such as marketing and the constrained "choice sets" available to consumers owing to governmental policies and the design of products by industry (Stern 1997).

size of housing and number of appliances) factors shape household energy consumption (Lutzenhiser, 1997). Hispanic and Asian households had significantly lower energy consumption than white or African-American households, and attached multi-family units were also more energy efficient. According to Lutzenhiser, conventional modeling approaches, with their focus on "typical" households and amorphous stocks of housing, fail to recognize the importance of the material environment's social dimension (e.g. status-graded buildings, equipment and behavior).

In contrast to housing, there is no evidence of saturation of demand for mobility (Schipper, 1997). In fact, private car use is increasing in almost every country, and the number of passengers per car is decreasing (Fuchs & Lorek, 2001). And, whereas the highest proportion of travel used to be for work, Carlsson-Kanyama and Lindén (1999) report that more than 50% of travel today is related to leisure time activities. They report further that an individual's life cycle stage and income significantly influence mobility, with the youngest and eldest in society traveling least, and the highest income groups traveling the largest distances (and a greater proportion of that distance by car and airplane). Interestingly, each succeeding generation seems to have higher expectations in terms of personal mobility, which does not bode well for the sustainability of household transportation.[9]

Food and nutrition demands by households clearly account for a large proportion of global land use (Heilig, 1994), and estimates of the total energy consumption used in the production, processing, storage, preparation, and transportation of food range from 20 to 30% (Langhelle, 2001). Only 10% of the energy consumed is actually used to produce the food; the remainder is consumed in the processing-distribution chain. As societies develop, generally a higher proportion of the diet is made up of animal proteins which are much less efficient than plant proteins, and have higher environmental impacts. Research efforts are underway to develop novel protein foods (Zhu, 2003), but given the degree to which food preferences are embedded in culture, it is unclear how successful such programs will be in convincing households to shift to new food types. Further, high input, intensive, commercial agricultural is a dominant determinant of freshwater quantity and quality (Batista, Silva, Galhardo, Viviana, & Cerejeira, 2002; Guo et al., 2004; Hall, Schreier, & Berka, 2001; Hunt et al., 1999).

Duchin (2003, 1997) and Reusswig, Lotze-Campen, & Gerlinger (2003) have proposed the use of household typologies developed by market research firms for the understanding of household types and their environmentally significant consumption patterns. Households are clustered according to factors such as income, geographic locations (urban, suburban, or rural), neighborhoods, and spending patterns. The approach also relies on identification of lifestyles, which will be discussed below. Such research seems ripe for the contribution of demographers and sociologists. However, there are potential limitations to the use of clusters defined for the purposes of marketing. Firstly, households are dynamic, forming and dissolving according to the life cycle stage (Entwisle, 2003). Secondly, the clustering methodology employed in these models are not developed according to theories of sustainable consumption but rather by the utilitarian desire to market more goods. Thirdly, there is as yet no agreed upon method to map particular cluster types to actual environmental impacts, though ecological footprints might offer one such approach (see below). Lastly, work on household consumption patterns has found unexpected complexity in consumption decision-making owing to the internal dynamics of households. Intra-household bargaining and power have direct implications for spending and savings behavior (Entwisle, 2003; Wilk, 1998).

This movement from national-level analyses of *per capita* consumption to households as units of analysis mirrors a movement in the population–environment literature from a concern for the depletion of non-renewable resources such as fossil fuels and minerals, to an interest in the dynamics of household decision-making vis-à-vis land use, fertility, migration and livelihood strategies. Thus, although the two literatures appear to be moving along parallel tracks, there is a great deal in common. Spangenberg and Lorek (2002) have contributed greatly to our understanding by shifting attention from the icons of conspicuous consumption—such as CD players, cell phones, household electronics and various kitchen gadgets—to the most environmentally significant forms of consumption, which have to do with the maintenance of daily household functions such as heating living space, eating, and travel to and from work and leisure activities. This represents an opportunity and a challenge: an opportunity in terms of focusing efforts on the redesign of fundamental structures such as housing, food and transportation systems, and a challenge because of the daunting magnitude of such a task.

Ecological Footprints and Material Flow Accounting

Measuring the resources consumed to support people's lifestyles has generated a number of intensive efforts to account for all environmental impacts of resource consumption, including externalities. Recently, two lines of research, ecological footprints and material flow accounting (MFA), have sought to create useful metrics using different approaches.

Developed by Rees (1992) and refined by Wackernagel and Rees (1996), ecological footprints has generated debate (see *Ecological*

Economics (March 2000)) about how it is measured and its ultimate usefulness for capturing the impact of humans upon the environment. Nevertheless, it builds on a long conceptual tradition in geography and ecology which coined terms such as 'ghost acreage' and 'shadow areas' when describing the amount of area used to produce a particular product or activity actually extended well beyond the boundaries of the site where the activity takes place (Deutsch et al., 2000). Research on ecological footprints derives directly from earlier efforts to estimate carrying capacity and represents an important refinement upon carrying capacity models.

The power of the ecological footprints analysis is its explicit attempt to account for externalities of human activity, and its recognition that, through trade, the impacts of resource consumption often occur thousands of miles from where final consumption takes place. Furthermore, it can generate a per capita figure of net carbon released or it can generate an area measure (hectares of biologically productive land), both of which are attention-getting figures. Some argue that the figures provide only limited insight or direction for policy, because the footprint is too unrefined and the models are not dynamic (Moffatt, 2000; Rapport, 2000). Nevertheless, the approach has generated considerable scientific activity, yielding promising future research and potential insights. These activities include assessing dynamics (feedback loops), accounting for temporal shifts, and spatial variability. Some have suggested incorporating the findings from ecological footprints research into dynamic simulation models, which are merged into geographic information systems. Because it has generated debate about the component contributions of human activity and their biophysical manifestations, it has also yielded productive research and findings regarding the accounting of ecosystem services (e.g. Jansson, Folke, Rockstrom, & Gordon, 1999). One line of research that has aided in the development of ecological footprint measures is the investigation of life cycle assessment of products (goods or services) (Pennington et al., 2004; Rebitzer et al., 2004)—these models and their related equations provide improved and important baseline information for the ecological footprints indices.

One of the debates in the ecological footprints literature is about how to determine from which unit of human activity or which ecological outcome to generate aggregate stocks. Research efforts have been expanded from evaluating industrial activity at particular types of factories or agro-industrial sites (Chambers & Lewis, 2001; Folke, 1988), to individuals (Best Foot Forward, 2000), to urban settlements (Ciu, Hens, Zhu, & Zhao, 2004; Folke, Jansson, Larsson, & Costanza, 1997), and to nations (Wackernagel et al., 1999). These debates are well-founded and buttressed by mixed empirical results. The population–environment literature has learned from its work with geo-referenced data that different levels of spatial aggregation yield very different relationships between demographic, social, and environmental outcomes (Entwisle, 2001). Although the ecological footprints research has generated a wealth of evidence, a major hurdle is to collect and account for the externalities of human activity at multiple levels of aggregation, from individuals to households, to communities to nations to the globe. Given the insights generated by the work on household consumption, it may be particularly useful for the ecological footprints research to focus on this social unit in a variety of different contexts.

Unlike ecological footprints, MFA does not attempt to combine the impacts of different types of consumption into a common metric such as carbon equivalents or hectares of biologically productive land. Instead, it measures the weight of all the materials that enter and leave an economy within one year, using the mass balance principle in a way that is analogous to economic accounts (Fischer-Kowalski, 2004). The inflows comprise extracted or imported materials to be used within the economy (e.g., wood, iron, minerals, petroleum, etc.), and the outflows comprise all material released to the environment as wastes and emissions as well as those materials that are stockpiled or exported to other countries. The principle behind MFA is that the sheer volume of material throughput in an economy matters, and that because the relative environmental impacts of different materials are often difficult to compare, it is preferable to reduce every thing to weight equivalents.[10] Thus, while a pound of a highly toxic substance is obviously more harmful than a pound of wood or iron, the two would be treated equally under MFA. According to Fischer-Kowalski (2004), "the use of weight as a unit of measurement in MFA (and also in other physical accounting tools) is a consequence of its feasibility, transparency and stability, and last but not least by the lack of alternatives." MFA has generated a number of derivative indicators, such as Domestic Material Consumption, which can be interpreted as waste potential, and Raw Material Equivalents, which equals the "up-stream indirect flows of the imported or exported products" (Eurostat, 2001).

A weakness of both ecological footprints and MFA is that it is not easy to generate these indicators at levels of spatial resolution below the nation or province. Thus, unlike population as a unit of analysis, "consumption impact units" cannot readily be located in space. The population–environment research community, and particularly the branch of the community that has utilized "gridded" population products to better understand population distribution in relation to environmental phenomena (Small & Cohen, 2003), could combine their techniques with the MFA or ecological footprints indices to make a significant contribution to our understanding of population-environment relationships. For instance, it would be interesting to explore the possibility of a gridded consumption pressure data set similar to the Gridded Population of the World or Landscan that would attribute standardized metrics to specific production or waste disposal activities to 1 km grid cells globally. While this would still not make the connection to where the final consumption takes place, it would represent a first approximation of the geospatial location of activities attributable to consumption.[11] However, generating a localized consumption impact unit would require taking into account estimates of the willingness of consumers to pay (accounting for relative prices, income, and tastes) and then locating the direct and indirect economic costs of producing the consumed goods (as those might be embodied in the observed and implied price of the good). Estimating consumers' willingness to pay is a key motivation for scientists investigating values, attitudes, behavior and lifestyles when explaining environment-consumption linkages.

Values, Attitudes, Behavior and Lifestyle

In most of the developed world much of what is now considered normative in terms of consumer behavior was not always thus. Historians trace the origins of the consumer culture to the breakdown of rigid class hierarchies, the rise of middle classes, and relaxation of religious inhibitions on conspicuous consumption (Wilk, 1998). Will the culture change again? Can self-definition by consumption bundle be substituted with societal values emphasizing satisfaction, satiation and sublimation (Kates, 2000)?[12]

Consumption behavior is determined by a constellation of factors, including *intrinsic* factors such as psychological makeup, education level, values, and attitudes, and *extrinsic* factors such as disposable income, time availability and social relations (Spangenberg & Lorek, 2002). Intrinsic factors shape consumer preferences, while extrinsic ones determine the degree to which preferences (or aspirations) can be realized. Given that behavior is first shaped by values and attitudes, research suggests that it is possible to shape people's attitudes towards consumption through public education campaigns or consumer awareness (similar to campaigns against smoking, drunk driving or other harmful activities).

Thorgerson and Olander (2002) find in their review of the literature that environmentally friendly behavior is indeed related to certain values, and that reasons for changes in values can be traced to three basic causes: differences between generations, changing conditions over an individual's life cycle, and periodic influences such as major personal or society-wide events. In their own research they explore the possibility that over the long term behavioral changes may shape values, yielding a reciprocal rather than uni-directional relationship. This has practical importance, since it is often argued that engaging consumers in low-cost activities such as recycling can reduce their incentive to undertake the more costly behavioral changes required for sustainable consumption because they feel that they have already ''done enough.'' In a panel study of Danish consumers, they found that values such as universalism (i.e. strong beliefs in ''protecting the environment,'' ''unity with nature,'' ''social justice,'' and ''equality'') can strongly affect the propensity of consumers to avail themselves of new opportunities to engage in environmentally sustainable consumption activities (in this case, source separation of recyclables). They argue that over the longer term, engagement in such activities—even if symbolic—can result in shifts in values which will influence other areas of consumption behavior towards enhanced sustainability.

Sanne (2002) argues that consumers are largely ''locked in'' to consumption patterns owing to technical, structural and political factors beyond their control. He notes that although many in the sustainable consumption debate point to the necessity of a change in values as a precursor to behavioral change, there is a note of resignation in such assertions because it is difficult to identify an agent for such a change whereas there are many consumption–promoting agents already at work. As a potential way out, he suggests that individuals are not only consumers, seeking to maximize personal utility, but also political agents and members of society. As consumers they may have little incentive to change the *status quo*. But as political actors, they can be convinced that for societal wellbeing, consumption patterns need to be reigned in even if it comes at a cost to their individual preferences.

Lifestyle has been an analytically fuzzy concept that nevertheless captures something that is missing in the values research, namely the way in which consumers identify with certain lifestyles (through trendsetting or emulation) as a way of defining themselves. Lifestyle preferences are shaped during formative years, and once they have been formed consumers literally buy into a consumption package—large homes, heated pools, good schools, etc.—that dictates their income needs and work patterns (e.g., dual income rather than single income households). Values certainly shape lifestyles, but because lifestyles can be clustered according to certain factors (discussed above), they may offer a means for policy analysts to identify levers for change that would be most relevant for each cluster, or to focus on those clusters deemed to have the most environmentally significant impacts. Once consumption clusters have been identified, policies might be developed according to different models or theories of consumption (see Wilk, 2002).

One limitation of the values, lifestyle, and culture literature has been careful decomposition of how price, income, and tastes affect consumer behavior. Determining which consumables are most sensitive to variations in taste, price, and income would provide important baseline information of policy relevance. The population–environment research with its emphasis on linking people to environmental outcomes might be very well situated to contribute important baseline information about variability in the elasticity of demand curves across locales.

Population–environment research could undoubtedly benefit from more research that explores environmental values as they relate to environmentally relevant behavior such as land clearing, tree planting, sustainable fishing, or consumer purchases. However, in post-modern cultures such as the United States and Europe, it seems at least plausible that there is an increasing disconnect between values and behavior, with individuals espousing many lofty "universalistic" and "benevolent" ideals that have little connection to their day-to-day behavior. Furthermore, if, as the household research suggests, the most environmentally significant behavior occurs at the "core" (the daily commute, household heating, and eating patterns) rather than at the "margin" (impulse buying, electronic gadgets), then it may be that the choice set is fundamentally constrained by factors that are difficult to change. Thus, one could promote shifts in values through environmental education or public information campaigns, but that would not impact the most environmentally relevant behavior because the potential to act on those changed values is limited by factors over which the consumer has little or no control.

The preceding discussion highlights three literatures, which directly address issues of consumption through the identification of critical social units of consumption (i.e. households), the accounting of the externalities generated by human activity, and the values shaping consumption decisions. As we have noted throughout, there may be important ways in which the population–environment and consumption–environment literatures could be bridged, or perhaps more modestly, in which they could cross-polinate. We turn now to a brief discussion of a field that has received significant funding and generated important empirical results about the relationship between population and environment.[13]

SITUATING LUCC RESEARCH WITHIN A PCE FRAMEWORK

The field of LUCC research implies, but is not explicit about, the importance of consumption. This research effort has received significant funding from a number of sources and generated important findings for the population–environment field and we propose that these findings are also important for the consumption–environment field. We briefly summarize this line of inquiry and suggest how it might be situated within a PCE framework. In so doing, we also suggest new ways in which the field might consider measurement of environmental conditions as they relate to human activity.

From studies in Brazil to studies in Ecuador, Thailand, India, Nepal, and the U.S. Great Plains researchers have made significant advances towards linking human activity to environmental conditions, particular land use, land-use change, land-cover or land-cover change. These studies have primarily focused upon social units smaller than a nation, frequently narrowing their attention to households and household activities with regards to land-use change or settlements in relation to land-cover change. The findings in this field of research are voluminous and we only summarize them briefly. From Thailand, Walsh, Welsh, Evans, Entwisle, and Rindfuss (1999) have found that the more local the social and spatial scale the more likely they are to find population and environment links. As the observational lens is expanded to counties, regions or nations, the relationship grows fuzzier—a critical finding for any attempts to view processes at larger scales (Evans & Moran, 2002; Evans & Kelley, 2004; Walsh, Welsh, Evans, Entwisle, & Rindfuss, 1999). The implication of these findings is that individuals, households, communities, and nations are nested sets of social relationships within interrelated ecosystems. Clarifying the nature, conditions, and character of the linkages between levels of analysis is paramount to overcoming the fuzziness.

Consistent with the findings of the earlier research on household and energy consumption, LUCC research has also observed that household formation has a more profound effect upon land-use/land cover change than does population growth *per se* (Liu, Daily, Ehrlich, & Luck, 2003; Lutz, 1994; Rindfuss et al., 2003). In the process of developing linked databases, refining and interpreting satellite imagery, and ''groundtruthing'' those linkages the empirical challenges created new insights for many of these observers and several excellent collections of research (for example, Fox, Rindfuss, Walsch, & Mishra, 2001; Walsh et al., 2002). One of the most challenging and potentially productive results of the collaboration of demographers, geographers and ecologists in this realm of research is realizing and then modeling the dynamics of household formation, growth, composition and dissolution. These are central interests in the field of demography, but the integration of spatial modeling has demanded more careful attention to the fluidity of household boundaries and household dynamics (Entwisle, 2003; Rindfuss et al., 2003). Recent work by Prskawetz, Leiwen, and O'Neill (2004) combines a dynamic modeling approach for households (Zeng, Vaupel, & Wang, 1997; 1999) to car use in Austria. Their work demonstrates that by decomposing spatial and household composition factors into demand and compositional components it becomes clear how the demand component contributes more to decisions about car use than the compositional factor. Nevertheless, during some periods compositional factors can be very important—smaller households and younger members in a population can significantly increase car use.

There has already been one attempt to look at the ways in which the consumption of ''lifestyle-related'' items impact global land-cover. Heilig (1994) estimates that more than 214 million hectares are used for the production of lifestyle-related products, such as stimulants, sugar, tobacco, oilseeds, and soy (which is used primarily for animal feed). Including the unknown area in illicit drug production, he suggests that up to 20% of the world's arable land area may be used for such ''luxury'' crops. This population-environment scholar's work shows that the luxury or lifestyle goods consumption appears to be significant, challenging the narrow range of environmentally significant consumption identified by social scientists within the environment-consumption field, namely housing, food and transportation.

Another way in which the LUCC research program might build a bridge towards the consumption–environment literature is to develop indices or measures of how particular land covers or land-use changes could be characterized in terms of consumption of resources. In some cases this is a relatively simple shift in syntax, answering questions such as how much biomass was consumed by clearing forested land to create a cultivated plot. In other cases, the effort might involve more nuanced measures which capture the potential consumptive quality and the foregone consumption or opportunity costs of particular land cover schemes. Encouraging LUCC researchers to consider consumption may shift the contributions of this line of research towards the fundamental questions asked by the environment–consumption field about environmentally significant outcomes and conditions. For example, research on global climate change has recently identified the importance of carbon sinks as a critical environmental factor for estimating the extent of global warming. Estimating which types of land cover and land use in which regions of the world yield more or less carbon sequestration has yielded valuable insights (Bloomfield & Pearson, 2000; Brown et al., 1995; Busch, Sathaye, & Sanchez, 2000; Canadell, 2000). A more complicated task, but one which may be feasible, is to develop measures of land cover that estimate species richness or potential biodiversity (Chu & Yu, (2002) offer a literature review on the topic). Another approach would be to develop land cover analyses that measure how land cover fragmentation in particular regions reflect diminished biodiversity or ecosystem health or regenerative capacity.

Similarly, the consumption–environment literature could learn from the land-use/land-cover change research about how to link household dynamics to patterns of consumption. Entwisle (2003) has noted that households grow, shrink, multiply and disappear. Further, particularly large changes in consumption may be highly correlated with points of household transition (moving, marrying, childbirth) (Entwisle, 2003). Thus, the research on households and land-use change suggests that particular moments in household life cycles are points to observe environmentally significant shifts in consumption.

CONCEPTUALIZING A PCE RELATIONSHIP AND FUTURE RESEARCH DIRECTIONS

We have attempted a broad overview of major consumption–environment research domains and their intersection with the population–environment research interests. In the section, ''Three Social Science Research Agendas about Consumption'', we reviewed three strands of consumption-environment research. In the first, social scientists have identified households as critical foci for environmentally significant consumption, and have narrowed down the range of household-level consumption to three major areas that have the greatest environmental impact: housing, food and transportation. In the second, we briefly reviewed recent work and debates about ecological footprints and MFA. Although the former is relatively nascent, it does build on earlier work in geography and it explicitly attempts to account for all the externalities associated with human activities as they relate to the environment. It is the accounting schemas that have generated the most debate, but which have also generated a wealth of empirical exploration and evidence. In the third, we reviewed the literature on values and attitudes. This appears to be the most challenging of the three topics, but we suggest that understanding shifting values and attitudes could make a useful contribution to a unified PCE research area. Applied and theoretical demographers, in particular, may be able to bring insights to these issues, given their focus on attitudes and behavior towards sexual activity and family planning. In the section, ''Situating LUCC Research within a PCE Framework'', we explored how the population–environment research that links populations to social units, such as households or settlements, has proven particularly insightful as

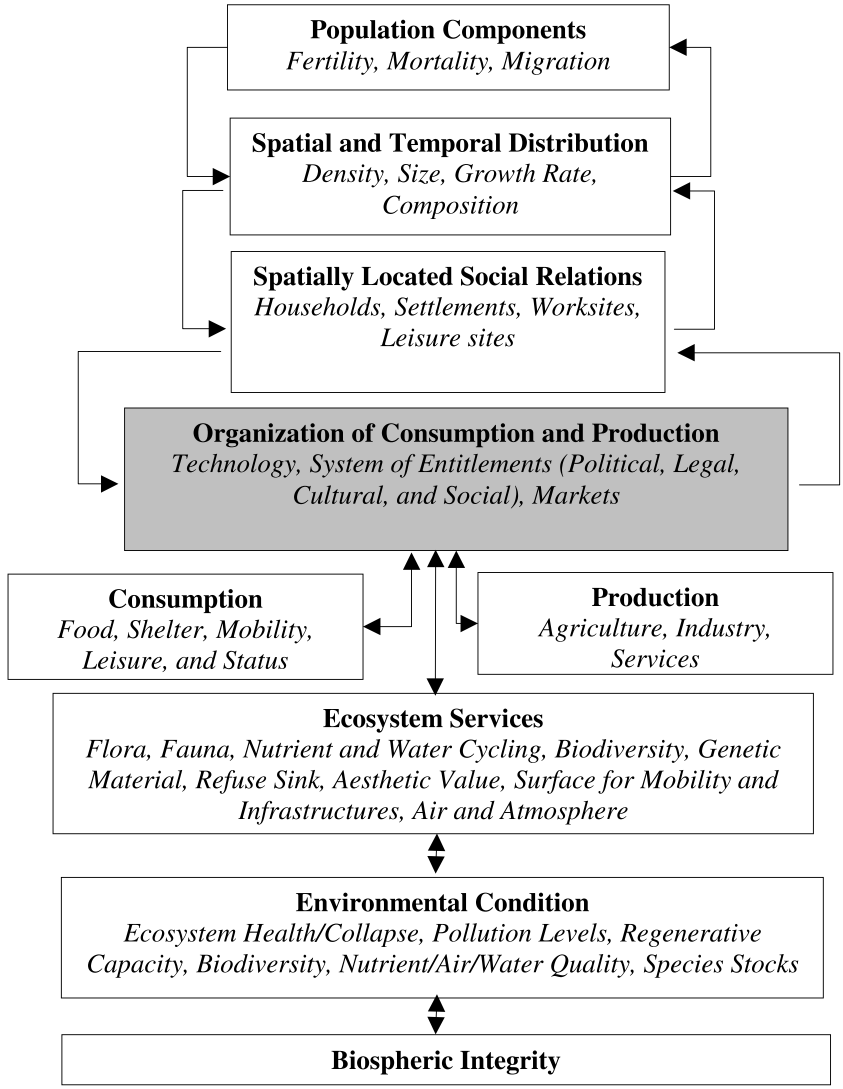

FIGURE 2. Population–environment conceptual framework (italic indicate conceptual dimensions and measures).

these social units are the primary sites for consumption decisions, and provides a natural bridge to the household-level research described in the section, ''Three Social Science Research Agendas about Consumption''.

Figure 2 provides a framework for thinking about the components of the population–environment relationship taking into account consumption. Each component is dependent upon a limited set of other components. We have also identified elements within each component that are more typically observed or measured. We have purposely under-specified the linkages and imposed a nested set of linkages between the components. At the top of the diagram are population outcomes and at the bottom of the diagram is biospheric integrity (Smil, 2002). In between are a set of derivative factors that eventually link to the central element—the organization of production and consumption. Within this we have identified four mechanisms that influence how humans interact with environmental services. These mechanisms are how technology affects efficiency of resource extraction and use, how entitlement regimes mediate allocation access to environmental resources, and how markets distribute environmental services. Environmental services are the critical proximate measures of environmental resource use by humans, and the ways in which environmental services are consumed affects environmental conditions and outcomes. Taking Smil's (2002) justifiable critique of environmental services approach in mind, we propose not only observation of human use of the environment, but consideration of the integrity of the whole system.

In our review we have mentioned in passing some ways that demographers and others working in the population–environment research field might contribute to a new population–consumption–environment (PCE) field, and ways in which consumption research may inform population–environment research. In hopes of stimulating further cross-fertilization, we conclude here with a list of research areas in which population–environment researchers may be able to make contributions to an integrated PCE research agenda:

- Household research: Population–environment researchers have long used the household as a unit of analysis. The understanding of demographers and others involved in land-use/land-cover change about the dynamics of household life cycles can contribute to PCE research by examining how dynamism and lifecycle stages affect consumption patterns.
- Values research: the knowledge-Attitudes-Practice (KAP) ''gap'' has been used in family planning research to explain why people express a desire to limit fertility but do not use contraceptives. Can this be a useful heuristic for understanding why people express concerns about the environment yet do not alter their purchasing patterns or environmentally damaging activities? The KAP gap approach could also help us to

understand consumer values and behavior vis-à-vis ''green'' products and willingness to pay (eco-labeling)

- Impacts of trade and consumption on the developing world: The ecological footprint ''deficit'' (the degree to which a country's consumption demands in terms of hectares of biologically productive land exceed its actual arable land area) represents one way of accounting for the spill over effects of developed country consumption patterns on developing countries (Wackernagel et al., 2002). There has already been useful research on the impacts of various export products (farmed fish or shrimp, bananas) on the local environment of developing countries, but more of this kind of research could usefully be undertaken (including manufactured products) and linked to studies assessing the awareness of consumers in developed countries and their willingness to curtail consumption of those products or accept substitutes.
- Modeling approaches: Lutz (1994) developed population–development–environment models of developing countries, and land-use/land-cover change modelers have explored likely scenarios of future land-cover change under various assumptions. Demographers and other population–environment researchers could contribute to the development of integrated PCE models with explicit environmental impact scenarios. These would make use of our understanding of households as consumption units, trends in income and societal values, and ecological footprints. More dynamic modeling approaches and broadening our attention to a wider array of environmental outcomes is now forecasted among many in the population–environment field (Lutz, Prskawetz, & Sanderson, 2002).
- Although much research has been conducted on Environmental Kuznets Curves (as described by Grossman & Kreuger (1995)), the proposition that the environment improves as income rises is still contested. Evidence from a variety of contexts and across a spectrum of environmental outcomes is contradictory. In some cases as nations get richer they tend to invest in environmental remediation, which reduces ambient pollution levels and results in a cleaner environment. However, as we have demonstrated in this essay, substantial evidence in the population–environment literature demonstrates that micro-level dynamics at the household or community level can lead to either dramatic change or substantial inertia. Just as with demographic transition theory 30 years ago, it will take a consumption approach towards understanding the micro relationships and their contribution to macro trends to really uncover the environmental transition proposed by environmental Kuznets curve adherents. Some argue that, just as countries experienced the demographic transition earlier than others, some countries appear to be undergoing incipient consumption transitions

(dematerialization, reductions in ecological footprint). What can we learn from those countries that can be transferred to the laggards?

CONCLUSIONS

In this essay, we propose bridging the literature between population–environment and consumption–environment. We began by describing the emergence of each field of study. We then described three aspects of the consumption–environment literature that seemed the most likely stepping stones for building a bridge to the population–environment literature. We then described how the LUCC literature might provide a suitable first entrée point for the consumption–environment literature. In the final section, we provide a framework for that bridge and outline several avenues of research for the future. Through this paper we have begun what we hope will become a greater cross-fertilization of ideas, methods and approaches between the two literatures.

ENDNOTES

1. A version of this essay was produced as a discussion document for the Population–Environment Research Network (PERN) cyberseminar from 17–31 May 2004 (see http://www.populationenvironmentresearch.org/seminars.jsp). The authors are grateful for the many insightful comments made by cyberseminar participants. A number of individual contributions to the discussion are referenced in the paper. We would also like to thank Landis MacKellar and one anonymous reviewer for their insightful comments which helped to hone our essay. This essay also benefited from the presentations made to and discussions during the IHDP PERN Workshop on population, consumption and the environment, 19 October 2003, Montreal, Canada. (Available at http://www.populationenvironmentresearchnetwork.org/workshops.jsp). Funding for this research was provided by the MacArthur Foundation through a grant to Curran. The authors are listed alphabetically and share joint responsibility for the text and content of the essay. Direct correspondence to either author (curran@princeton.edu or adesherbinin@ciesin.columbia.org).
2. We note that this is a primary focus, but not the only focus. There is also a significant body of research and policy about environment outcomes as a result of end product consumption, specifically around recycling behavior, policies, and programs and waste management. Industrialization and industrial production have garnered the most attention, including waste management as a result of industrial production.
3. For some examples of this growing literature visit the PERN website (see next note). Some references in this literature include: Davis, Kingsley and Mikhael S. Bernstam (Es.), 1990. *Resources, Environment, and Population: Present Knowledge, Future Option.* Supplement to Volume 16 of *Population and Development Review*; R. E, Bilsborrow, & H. W. O Okoth Ogendo, ''Population-driven Changes in Land Use in Developing Countries,'' *Ambio 21*(1), 37–45 (1992); Jolly, Carole and Barbara B. Torrey 1993. *Population and Land Use in Developing Countries.* Washington, D.C.: National Academy Press.; Marquette, Catherine and Richard Bilsborrow 1997. Population and Environment in Developing Coun-

tries: A Select Review of Approaches and Methods. In *The Population, Environment, Security Equation*. Vol. 13. Edited by B. Baudot and W. Moomaw. New York: MacMillan.; Ness, Gayl, William D. Drake, and Steven Brechin 1996. *Population–Environment Dynamics.* Ann Arbor: The University of Michigan.

4. http://www.populationenvironmentresearch.org/index.jsp
5. In fact, micro-level population–environment research was criticized during the cyberseminar as relying too heavily on the notion that populations subsist on the local resource base (see panel statements by M. Fischer-Kowalski of 19 May 2004 and R. York of 17 May 2004).
6. This work builds on that of MacKellar, Landis, Lutz, Prinz, and Goujon (1995). In their study of population growth, energy use and CO_2 emissions, they demonstrated that using per-person measures in the I = PAT model as opposed to per household measures in an I=HAT model predict dramatically different consumption and emissions levels in developed countries and no difference in developing countries. In their accounting exercise, they estimated the contribution of population growth (relative to changes in income and technology) towards the growth in energy consumption or CO_2 emissions levels. They find that when population growth is measured using households, its contribution towards energy consumption is 76% (income and technology contributing only 24%) in developed countries. When using a per capita measure in the model, the contribution of population growth towards changing energy consumption falls to 33% in developed countries (about the same for developing countries). This comes about, even though fertility declines decelerate population growth, because the population age structure changes with more heads of households living longer (MacKellar Landis, Lutz, Prinz, & Goujon, 1995, p. 860).
7. It should be added, though, that by focusing on households we miss some sub-populations, such as students and institutionalized people.
8. Government consumption mostly takes the form of goods and services, which largely takes the form of employee wages. However, an understudied, but likely important impact of government consumption on the environment is that related to military expenditures (equipment, toxic products, and land use).
9. Zacarias-Farah and Geyer-Allely (2003) project that by 2020 the vehicle stock of OECD countries will grow by 32%, the total vehicle kilometers traveled will grow by 40%, and air travel will triple. Much of this is due to projected increases in tourism.
10. In her contribution to the cyberseminar discussion, Fischer-Kowalski (2004) notes that depending on the purpose of an MFA, and the specific problems on which it is focused, it may be appropriate to apply environmental impact weights to different types of consumption.
11. Sutton and Constanza (2002) produced a gridded data set of the GDP which was based entirely on a translation of luminosity of lights at night. This data set, however, attributed virtually zero economic production to agricultural lands, which apart from greenhouses are not lit at night.
12. Duchin (2003) writes that one objective for sustainability science is to ''recommend alternative behaviors that can substantially reduce the physical impact of household activities on the environment and to identify material and social contexts in which households might come systematically to consider alternatives.''
13. For students of the sociology of knowledge or history of science, the population and environment field offers a very important and contemporary example of how public discourse, technology, government agencies political imperatives, and social movements shaped an intellectual field of knowledge. The coincidence of interests that lead to the coalition between NICHD, NSF, and NASA was one factor generating the well-funded initiatives of human dimensions of global climate change and the LUCC field.
14. This formed a major strand of the cyberseminar discussion.

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