Ecological Economics 172 (2020) 106606

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Commentary

Implementing ecological economics

David Batker

Batker Consulting LLC, 14420 Duryea Ln S., Parkland, Washington 98444, USA

1. Introduction

The crises humanity and nearly all species face are largely driven by economic decisions. Today's dire need to implement ecological economics in real places, with real people, real institutions, and real policies and projects requires an expanded commitment for the next thirty years, to organizing research so it can be more effectively applied. Economies and the world's ecosystems need a more rapid implementation of ecological economics, and healthy economic transformation, enabled by nimble, timely, and coordinated research. Students should be trained by working in collaborative transdisciplinary research, solving current actual problems. The focus of this paper is to highlight the scale of change that we can effect at local to global geographies, if researchers and practitioners work together. This is highlighted with a quick overview, and two cases, one concerning ecological restoration at scale in the birthplace of ecological economics, the Mississippi River Delta, and another one concerning immediate opportunities concerning the global plastics crisis.

2. Overview: ecological economics and change

From a practitioner's perspective, ecological economics should by physically transform the relationships between the economy, humanity, and natural systems toward sustainability. This requires change at local and global scales. It requires cultural change, social change, and institutional change. It requires transforming how we access resources, produce, transport, and consume goods. Aspects of this grand agenda, such as the climate crisis, are of a global scale and require global coordination. Other more local challenges, such as land use planning, can be solved locally. Respecting and building upon the benefits of vast diversity, of nations, of cultures, of indigenous peoples, and of local communities mean that we must be committed to diversity and pluralism, from methods pluralism to implementation.

The stakes are high. Lives and species hang in the balance. The real policy world is so extraordinarily dynamic, flawed, and yet shocked with sudden windows of opportunity that may suddenly open wide and then slam shut. Thoughtful long-term planning and careful strategy pay off in policy change. Working with practitioners who deeply understand the issues, politics, and institutions requires paying attention to practitioners and stakeholders in designing analysis and policy.

Additionally, many people implementing ecological economics change may not be fully informed about its existence, and thus do not fully utilize research that would advance their work. Yet some make good progress. Understanding the reality of this dynamic change is essential to effectively implementing ecological economics and creating better local, national, and international economies.

Ecological economics is science-based, recognizing physical reality. It is also ethically grounded. The economy is a subsystem of a finite planet. We live within biophysical limits. Within those limits we must make ethical decisions about justice and distribution. In the short-term, the economy can exceed sustainable limits, damaging the natural systems and vastly shrinking biocapacity, as in the recent loss of one quarter of the Mississippi River Delta wetlands to open water.

Our ranks are few, yet our skills are urgently needed by so many who are ready to collaborate with us for change. Can we better allocate our skills and time to achieve shared goals? Perhaps more time spent implementing policies we generally agree upon would open more and larger doors for policy advancement and increased research funding.

It seems that ecological economists generally agree on these points:

1. There are physical scale limitations to the physical economy. This is likely the most important premise of ecological economics.
2. Recognizing that resources, goods, services and time are not unlimited, real decisions about distribution and justice are made far more acute than in that imaginary world of unlimited physical growth. Helping resolve issues of justice is at the core of ecological economics.
3. Limits to sources, sinks, and throughput within the context of a just economy also impose new challenges to the allocation of resources. Understanding these limits allows more equitable provision of a vast diversity of desired goods, services and intangible experiences. Many aspects of our current global economy are wasteful almost beyond measure. Improving allocation and throughput and adjusting demands and desires are ecological economic goals essential to achieving sustainability and justice.

These are goals that practitioners pursue across the full gamut of issues. We will likely never all agree on anything. However, let as many of us as possible collaborate to empower communities to come to agreement on solutions and successfully implement them.

E-mail address: dbatker@outlook.com.

https://doi.org/10.1016/j.ecolecon.2020.106606
Received 9 August 2019; Received in revised form 4 December 2019; Accepted 26 January 2020
Available online 04 March 2020

As I look back on the thirty years of the journal, I deeply admire the depth and breadth of work accomplished. I am also struck by the time and print spent on debates about “theoretical rigor.” Those that are untethered to empirical experience may border on “I'm right, you're wrong” discussions. I do not say that these discussions are not productive. However, it sometimes feels that we are employing emergency room nurses and doctors in coffee table conversations, rather than having them work to save patients in the emergency room. Many ecosystems and much of humanity need and would welcome emergency ecological economics care, which is often unavailable.

We do believe in plurality. Let those with differences apply their alternatives and let's measure the relative performance. We have a common vision that ecological economics solutions should be diverse. On this topic, I have learned a great deal in working with indigenous peoples. Of fifteen tribes in the Columbia River Basin, no two have the same economic policies. Yet all may implement what I would consider to be ecological economics. My recent experience working with Columbia River Basin tribal leaders and members was impressive in many respects particularly in that the fifteen tribes generally manage conflict and collaboration quite well, often simultaneously. Perhaps the basis of this functionality is mutual respect arising from the view that “We have been and will be neighbors for generations.” Can we cultivate better mutual respect within our communities and with partners to better manage conflict and collaboration simultaneously, and thus implement ecological economics more rapidly? In a future article of sufficient length, I will provide further insight from this experience.

In setting a research agenda bent upon implementing needed change, can we emphasize our shared worldview and goals, empowering our diversity in views, approaches, methodologies, communities, and policies, to implement applications as quickly and successfully? In reality, we must often do the best we can with the resources, time and capacity available. Greater discussion of theoretical rigor under real-world constraints and political conditions would be helpful.

Theoretical rigor and internal consistency are not unimportant, but they are also not penultimate. Our community is not so delusional to think that developing theories alone is sufficient to transform society. To be successful, our work must resonate with voters, decision-makers, stakeholders, and the public. Applications are messy. “Win-Win” solutions are rare. Communities are often split, faced with tremendously difficult choices. The realities of racism, ethnic conflict, sexism, and the flexing of raw political and economic power are pervasive forces with which practitioners must contend. The next thirty years of ecological economics research should drive constructive change by empowering practitioners and implementers of ecological economics to achieve progress and transformation in these more dynamic real-world settings.

There may yet be no end to some internal debates in our community, but I am hopeful for progress. Let's test theories and report the results. Consider the voluminous discussion on valuation. Monetary valuation provides a description of a subset of value. Not all values that exist can be identified. Of values identified, not all can be quantified. Of values quantified, some can be monetized. Context is critical. The Philippine National Economic Development Authority and the Federal Emergency Management Agency (FEMA) are required by law to include monetization of benefits.

Lola Flores, I and colleagues worked with 15 Native American Tribes in the Columbia River Basin (Flores et al., 2017) in which the tribes discussed valuation. In a superbly functional process, Tribal leaders chose a hybrid approach to valuation. They selected valuation with respect to some ecosystem services as well as power pricing and modeling with respect to proposals to alter Columbia River dam operations for salmon restoration. This was because better managing water for salmon reduces electrical generation income in some dry years for the Bonneville Power Administration (BPA). That monetized income is important to BPA. The tribes chose to have no monetary valuation concerning tribal rights, first foods, and cultural values (Flores et al., 2017). The paper also proposes that ecosystem function be a primary goal of the Columbia River Treaty (Canada/U.S.) with power production and flood risk reduction. In my opinion the question of monetizing values or not monetizing values, can only be answered in the context of community and application. I provide two real-world examples here, one with valuation, and one without valuation to highlight the importance of pragmatism. Ideology, concerning valuation (and other topics) is a guide we want to avoid.

To highlight the possibilities of academic research to fundamentally change society and the environment at scale from a practitioner's point of view, for me there is no better beginning than a return to Louisiana, where *Ecological Economics*, the journal, and the journey of my career began. I went to Louisiana State University to study with Herman Daly in 1985, and was a graduate student in 1989 when Herman, Bob Costanza and others founded the journal. My career spans the birth of the journal to the present day. Throughout those thirty years, I have used the robust research published in this journal to make change. Yet I often felt the need for more organized, strategic, targeted, and timely research. Louisiana is evidence of both our success when academics and practitioners work together and of urgent ongoing need.

3. Louisiana and restoration of the Mississippi River Delta

The stakes are high. The Mississippi River Delta, the largest river delta in North America, contains 40% of US coastal wetlands (Day et al., 2014) and is an economic and biocapacity powerhouse. It is an excellent example of how ecological economic research can promote large-scale change, if research programs are geared more toward implementation and less toward theory. The delta has lost one quarter of its coastal wetlands (485,000 ha) in eighty years and now faces rapid sea level rise and more intense storms (Day et al., 2014). Business as usual, such as oil and gas development with unrestored canals and wetland loss impacts, would continue the ecological collapse of the delta, and increase sediment loss, increase flooding and natural and induced subsidence, increase salt water intrusion, water pollution, hypoxia, and threats to fisheries and biodiversity, and increase loss of natural storm buffering and natural waste treatment. Such environmental changes would have dire impacts on navigation, industry, farming, shipping, housing regional communities and cultures, and people's lives. Continued loss of land could wreak havoc on the 2.2 million people living in coastal Louisiana, and devastate economies and trade upstream. Our work on the Mississippi Delta in restoring ecosystem function can provide valuable lessons for restoring other deltas around the world facing similar problems.

The State of Louisiana, with a Democratic Governor and a Republican controlled House and Senate, is currently implementing what is likely the world's largest estuarine restoration plan, with a suite of projects estimated to cost $50 billion dollars. The 2017 Coastal Master Plan rebuilds and protects significant portions of the delta (CPRA, 2017). This project is largely the result of lengthy collaborations among governments, academics, non-profits, communities, scientists, practitioners and ecological economists. In early 2019, the State of Louisiana approved $2.2 billion for the construction of two large sediment and water diversions in the Mississippi River, to facilitate the restoration of tens of thousands of acres of wetlands and protect another 100,000 acres. The diversions will create new rivers in the delta, distributaries with a capacity of 75,000 cubic feet per second (cfs) and 30,000 cfs. The state is also considering a diversion that would be roughly the size of the Columbia River at 250,000 cfs. Data show that wetlands with access to sediment, nutrients, and fresh water can grow aggressively, adding elevation, and can even outpace rapid sea level rise, and that diversions can provide these benefits (Day et al., 2005). Rapidly growing wetlands and associated cypress forest also sequester carbon.

As this journal was being founded, Herman Daly, Bob Costanza, and Steve Farber were working on ecological economics and aspects of wetland restoration, wetland valuation, and Mississippi River Delta

biocapacity. John Day, LSU emeritus wetland professor, has worked for over forty years studying the delta, coordinating teams of scientists, and campaigning for restoration (Day et al., 2005). I published my own first paper on the impact of oil and gas canals on ecosystem services in 1990 with the Louisiana Geological Survey (Batker et al., 1990). Paul Templet, an LSU ecology professor and the first head of Louisiana's Office of Coastal Management is well versed in ecological economics. It is impressive how many academics, NGO staff, state officials, and decision-makers have an understanding of, and respect for ecological economics in Louisiana. Delta land loss was recognized as a crisis prior to Hurricanes Katrina and Rita in 2005, but the devastation caused by these storms stunned Louisiana and the world. Paul Kemp left the Hurricane Center at LSU, went to Audubon, and helped coordinate a host of NGOs promoting action. The robust NGO community in Louisiana has collaborated exceptionally well.

Shortly after the destruction wrought by Hurricane Katrina, an academic article published in *Ecological Economics* argued that this crisis opened a policy window to address long-festering problems (Farley et al., 2007). At the same time Day, myself, Kemp, and others participated in a series of meetings with the U.S. Army Corps of Engineers arguing for the recognition that wetlands provide storm buffering. Wetlands dampen storm surge and attenuate wave action. The Coastal Protection and Restoration Authority was strengthened and launched the first Coastal Master Plan in 2007. Ecological economics workshops and presentations were held in the state between 2006 and 2010. Perhaps a turning point was the realization that the solution must be at the sale of the problem, and the delta is large.

Roel Boumans dedicated a University of Vermont graduate class to focus on research for valuing the full delta's ecosystem services, and making a case for the scale of the asset and the value of restoration. The students were electrified by the work. It is essential that we teach students how to apply ecological economics in real world settings. Working in partnership with many such classes, I feel that the best way to teach transdisciplinary science is through grappling with actual transdisciplinary problems, and students flourish when they see their work contributing to communities and solutions.

In 2010, the organization I co-founded and presided over from 1997 to 2018, Earth Economics, released an estimate of the value of ecosystem services from the Mississippi River Delta, showing $1.3 trillion in value over one hundred years, just as the Deep Horizon spill oiled the northern Gulf of Mexico. The report, Gaining Ground (Batker et al., 2010), was covered by print, radio and TV press nationwide. The state, elected officials, news, and citizens still refer to that report. It is the third reference in the 2017 Louisiana Coastal Restoration Master Plan (CPRA, 2017), and is very well-known in Louisiana. Our report, Gaining Ground applied an ecological economics approach, and research by ecological economists from the 1980s through the publication date. Perhaps most critically, research for the report was conducted by ecological economics graduate students at the University of Vermont Gund Institute. Pulling disparate strands of research together into a coherent whole effective for decision makers was a herculean effort, the essence of transdisciplinary work, and good training for students, academics, and practitioners. Students were electrified by the press and effectiveness of the report.

A two-year science and economics envisioning process sponsored by Paul Kemp and Audubon culminating in the 2014 Springer publication of *Perspectives on the Restoration of the Mississippi Delta* (Day et al., 2014), brought together engineers, wetland ecologists, fisheries scientists and myself (as an ecological economist). It added to the substantial physical science research, modeling, and planning CPRA generated and drew upon for the 2017 Coastal Master Plan, identifying specific restoration projects (CPRA, 2017).

Rivers naturally build deltas. One of the primary paths to restoration is to redistribute river sediment by restoring the distributary functions of the river and its delta. The Mississippi River transports over 200 million tons of sediment each year, only half of the historic sediment load. Much now captured by dams (Day et al., 2014). That sediment is vast and valuable delta-building material. Recapturing that sediment for delta restoration is a top priority for expanding delta ecosystem services and biocapacity.

By 2015, the State of Louisiana was ready for an economic study of four specific large Mississippi River sediment and water diversions, based on physical modeling. The first two diversions would cost over $2 billion. There was no debate about monetization. The state expressly wanted to understand the monetary benefits of the projects and scenarios. CPRA hired Royal Engineering, who requested me for their team (while I was at Earth Economics) to conduct a socio-economic analysis of four large sediment and freshwater diversions in the Mississippi River.

My colleague and ecological economist, Dr. Tania Briceno, provided a virtuoso performance of the necessary skills in leading our team. Working with a visionary engineer, Mitch Andrus, Vice President at Royal Engineering and his team she brought the physical and social sciences together in a form that helped successfully secure resources for restoration at scale. On a daily basis, Tania communicated with sediment scientists, biologists, engineers, and state officials, synthesizing and coordinating the physical and social sciences. Tania brilliantly combined ecological economics with traditional tools, such as IMPLAN, a model for calculating jobs, as well as regional multipliers, tax revenue, and other pertinent data. For example, increased or decreased shrimp catches were based on fisheries modeling that provided stock and catch estimate results for six different restoration scenarios.

The research was formidable. The state had separate physical and biological teams, modeling six diversion scenarios for fifty years across an enormous landscape, providing sediment, water quality, salinity, and other physical data. Two separate fisheries teams modeled the stock and catch estimates for over forty fish and shellfish species. The physical models did not share geographic, political or economic boundaries. At one point, scientists provided our team with six versions of hourly salinity data across thousands of square kilometers for fifty years, when the actual question we needed to answer was, “where will oysters be?”

To implement ecological economics, our training must include skills for working in transdisciplinary teams that can synthesize the physical and social sciences into actionable policies, projects, and behavioral changes. I fear that at times our community does not understand how difficult implementation really is, and what skills it takes to bring ecological economics to fruition in a world of brutal politics.

Another vital and practical economic skill in the implementation of pioneering work is judging where to pioneer and not to pioneer, when time and resources are obviously limited and results on deadline are required. In our diversions study, the provisioning of some ecosystem services, such as fisheries stocks and productivity, were extensively modeled and those results provided the basis for valuation. In other cases, such as storm protection, more detailed modeling would have required another three years of work, and that time was not available. Valuation proceeded with a benefit transfer approach to storm buffering. Costanza et al. (2008) is an excellent study, which in light of the increasing intensity of hurricanes and frontal storms, with rapidly rising damages, certainly underestimates the true buffering value that wetlands provide today and will provide in the future. Ecosystem services, market and non-market values were calculated for six fifty-year scenarios including a “no action” scenario. Not purely ecological economics or purely traditional economics, the study (Royal, 2016) was roundly accepted by reviewers, the state, environmental organizations, Republican and Democratic decision-makers, and even by many of those who opposed diversions.

As is true of many shifts to sustainability, not everyone is a winner. Oysters were projected to decline for eleven years, as fresh water poured into brackish areas long impacted by saltwater intrusion. Oyster modeling showed significant expansion beyond current productivity after these eleven years as the belt of estuarine oyster habitat expanded

in a larger arc toward the Gulf. Historically, the Mississippi Delta experienced sheet flow of fresh water at flood stage across a larger area of the delta, providing a larger belt of oyster habitat extending over 100 miles out into the Gulf of Mexico (Day et al., 2014).

As a result, a new set of questions arose concerning the impact to oyster leases and harvesters, questions about distribution, the disproportional impact, and potential compensation. This corresponded to the distribution/justice goals of ecological economics. These issues were not included in the original study scope developed by CPRA, but now decision-makers are discussing these questions.

The diversion study was not a benefit/cost analysis, but a socio-economic analysis, which allowed for a very important discussion of cultural value. But make no mistake, the dollar values were critical to justifying $2.2 billion in engineering and restoration infrastructure expenditures.

It was the first time that residents, industry and elected officials from ten affected parishes could see the results of science-based economic modeling for restoration at this scale. The opposition to restoration and diversions, though still vociferous, shrank. After approving environmental permitting and engineering design in 2017–18, the State of Louisiana approved the construction of the Mid-Barataria and Mid-Bretton sediment and water diversions in the Spring of 2019. Decision makers may not fully understand the valuation (or other economic) models, and no one was under the impression that economic valuations spanning fifty years are precise. But decision makers across the political spectrum wanted an understanding of ecosystem services, of cultural value, and of the physical and economic implications of no-action vs restoration scenarios across fifty years. With the Royal Engineering team, Dr. Briceno and I provided that.

In July 2019, for the first time in recorded history, a hurricane (Hurricane Barry) struck at the same time that the Mississippi River was at flood stage. Hitherto, spring floods and summer hurricanes had never coincided. Had the path of Hurricane Barry been forty miles east, pushing a storm surge up the mouth of the Mississippi River, it would have backed up the massive flow, and breached levees, which would not be reparable for months. This scenario has not been considered possible in the past. With the Morganza Spillway and Bonnet Carre Spillway in place, diversions would have provided additional distributary outlets for the river's flood waters which would also deposit sediment in the delta.

Implementing real ecological economics solutions at scale, in the midst of current political and social realities requires robust and timely research that utilizes many economic tools while thinking outside traditional economics, and perhaps even ecological economics boxes as well.

Restoration in any geographic area can benefit from answering the questions: what is the scale of restoration needed? What are the distributional and justice implications of restoration alternatives? How can resources be efficiently allocated to achieve desired ends? What specific economic policies can bring about ecological restoration fairly (such as ensuring those responsible for causing land loss pay for the restoration of land loss that they caused)? What restoration actions should be taken? How should restoration be paid for? What happens to communities outside a restoration plan that are likely to be displaced by knock-on effects such as sea level rise and storm impacts? What is the appropriate timeframe for implementation? For many challenges, these are important questions that need answers now.

The Louisiana Mississippi River diversions example is an area where ecological economists have engaged nearly continuously across four decades. It is a relatively bounded geography with relatively abundant scientific and social data and a history of ecological economics research somewhat longer than the journal. This is an exceptional case. Ecological economists need not work for over thirty years on a topic to make progress, because practitioners have already put in thirty years of work.

4. The plastics crisis

Recent development in the global plastics crisis provides an example of global actions and opportunities. If ecological economics researchers do not engage with practitioners, NGOs will move forward, even if not explicitly informed by ecological economics research. Many are already in alignment with the ecological economics goals of scale and justice. The Basel Convention, Bamako Convention, Basel Ban, and other recent actions on plastics embody ecological economics principles regarding scale, distributive justice, and trade that should be banned or regulated. The impressive history of the Basel Convention and the May 2019 decision to regulate the trade in mixed and contaminated plastic waste under Annex II, Wastes for Special Consideration, (Basel Convention, 2019a) provides a timely example of both thirty years of groundwork laid by practitioners and the remarkable opportunity for ecological economics researchers to help make change at scale right now. Ecological economists did play an early and important role.

In 1988, there was a debate within the World Bank about promoting the export of hazardous waste to African nations, which would then be a source of foreign exchange, I was present (an intern in the Training Department) during that discussion. Herman Daly and Robert Goodland argued for a total ban on such shipments, and actually won the day, with a World Bank policy against lending to promote hazardous waste shipments.

As the U.S., Europe, and Japan regulated hazardous waste disposal nationally in the 1970s and 1980s, hazardous waste began to be shipped, primarily to Asia, Africa and Latin America. Coordinating with NGOs globally, Greenpeace documented over 600 cases and 10 million tons of hazardous waste dumping (Vallete and Spalding, 1990). In 1989, as a result of the outcry over the growing waste trade, the Basel Convention was adopted, with the purpose of controlling the “Transboundary movements of hazardous wastes and their disposal….” (Basel Convention, 2019a).

In 1991, then World Bank Chief Economist Lawrence Summers, perhaps unaware of World Bank policy, signed his infamous memo stating: “I think the economic logic behind dumping a load of toxic waste in the lowest wage country is impeccable and we should face up to that.” The memo was leaked and faxed to over 400 newspapers worldwide. In 1991, African nations lead the way and adopted the stronger Bamako Convention, banning the importation of hazardous wastes, and spurring on more restrictive negotiations at the Basel Convention.

Outrage over the Summers memo, and the Bamako Convention, and NGO advocates from dozens of nations, helped galvanize nations to secure the adoption of the 1995 Ban Amendment to the Basel Convention (Decision III/1), which entered into force on September 6, 2019 when Croatia became the 97th country to ratify the amendment. The amendment bans the trade in hazardous and electronic wastes, including obsolete ships from OECD to non-OECD nations.

However, the EU and countries in Asia, Africa and Latin America had effectively implemented the Ban Amendment for two decades with national legislation and aggressive enforcement. As a result, the dumping of Basel-defined hazardous waste declined dramatically. The U.S. is not a party to the Basel Convention, let alone the Ban Amendment. Subsequently, the trade then shifted to “recyclables” that still contain hazardous materials, such as car batteries and electronics.

Jim Puckett, Executive Director of the Basel Action Network (BAN), has worked on the trade in hazardous and other wastes for over three decades. He was the first to document the massive electronic waste dumping ground in China in 2001 and has been working successfully to stem the flow of US techno-trash to Asia, Africa and Latin America. By placing GPS trackers in electronic waste, BAN has not only caught cheaters, but collected the necessary evidence to send them to prison for fraud (BAN, 2019). Two owners of a Seattle electronic recycling company were sentenced to prison in October 2018 for not reporting income from illegally exported electronic waste tracked by BAN

(Rosenburg, 2019).

Jim has attended Basel meetings from the beginning, and had the foresight, in the 1990s, when the delegates had the momentum on the larger toxics issue, to advocate for an expansion of the Basel Convention's remit. With foresight, Annex II was adopted. It gave the Basel Convention governance over the trade in household wastes, though Annex II remained largely undefined and dormant as the convention's implementation focused on regulating hazardous wastes.

4.1. Fast forward to the plastics crisis

Plastic is typically a household waste. It is also a petroleum product contributing to C02 emissions and thus climate change. Global plastic is exceeding sustainable scale: plastic production and throughput far exceed the globe's capacity to degrade plastic. As a result, plastic is piling up in oceanic gyres, in the deep sea, on beaches, across terrestrial landscapes, filling landfills, and even inside organisms from plankton to humans.

The plastic waste burden is disproportionally distributed (shipped) to poor communities, particularly in Asia. The growing global awareness of vast volumes of plastics waste in the oceans and on land has recently catalyzed action.

China, which once imported well over half of the world's electronic and plastic waste, first banned electronic waste imports, and then, under the 2018 National Sword Policy, extended the e-waste prohibition to wastes of all kinds, including unsorted “recyclable” plastic, and then enforced these bans. Containers of plastic “recycling” and waste were diverted from China in early 2019, and suddenly mountains of additional plastic waste appeared in Indonesia, Malaysia and other countries in the early months of 2019.

BAN and other NGOs advocated that plastic be listed as Basel Convention-regulated waste under Annex II. Norway brought the proposal forward at the Basel Convention Conference of the Parties, in April 2019. During the meeting, China suddenly proposed additional and stronger restrictions on plastic than the Norwegians. Despite opposition from the global plastics industry (which attended the meeting in force), and from the U.S., the motion passed by consensus for the 187 nations that are parties of the Convention in May 2019.

The Basel Convention Secretariat press release announced the decision (Basel Convention, 2019b). “Governments this week amended the Basel Convention to include plastic waste in a legally-binding framework which will make global trade in plastic waste more transparent and better regulated, while also ensuring that its management is safer for human health and the environment.”

The once orderly global trade in plastics was thus thrown into turmoil. “Better regulated” means that countries must now be notified of plastic waste imports and can refuse plastic waste shipments. Malaysia and Indonesia quickly did so and other countries followed suit. The restriction on the U.S. is far more severe.

Signatories of the Basel Convention cannot engage in the trade of Basel Convention regulated wastes with nations that are not parties to the Basel Convention. The U.S. is not a party to the Basel Convention. This means that mixed U.S. plastic waste can no longer be shipped to non-OECD nations who are Basel Convention parties. There are 187 Basel Convention party nations. This leaves few countries open to used plastic imports. Even North Korea is a party to the Basel Convention. That coupled with China's recent decision to ban the importation of plastic, electronic and other “recyclable” wastes, has sunk the economics of plastic recycling programs across U.S. cities and counties. Programs are no longer paid for “recyclable” mixed plastic waste. For example, in June 2019, the City of Tacoma announced a list of no-longer recyclable plastics. In the same month the City announced steep increases in recycling charges because the program went from earning over $1 million/year to losing $1 million/year instantly (Driscoll, 2019 DDr). European and Japanese programs are also in crisis. As Asia shut the doors, there has been a sudden stockpiling of European plastic. Malaysia, Indonesia, China and other counties have already turned back containers of “recyclable plastic” which they have no capacity to deal with.

Indeed, As Puckett explained “recycling plastic” is largely a fraud. One reason for this statement is the fact that plastic cannot be recycled like copper. As Georgescu-Roegen argued, the first and second laws of thermodynamics preclude 100% recycling, even of metals and glass. Plastic is actually “downcycled” into a lesser quality product, and after two such cycles becomes predominantly unrecyclable garbage. The costs of plastic waste, including terrestrial and marine pollution, the human health impacts of microplastics, and many more costs, remain under- or unmeasured. The policy window is now wide open, globally, because local and national jurisdictions can no longer simply stuff plastic into containers and ship it to China or other countries. The economy of plastic waste is in flux and ripe for ecological economics policy.

The Break Free From Plastics (BFFP) group is a global alliance of NGOs that has called for “peak plastic” (BFFP, 2019), a global scale limit to plastics production. Can ecological economics rise to the occasion and provide needed, timely research?

Puckett notes, “We need the economic tools to deal with the plastics crisis, and honestly I don't care if it's called environmental or ecological economics, just give me the numbers, and economic principles to show that plastic costs us dearly in dollars and cents when we continue to pump out single-use plastics, flood our territories and oceans with them, and dump them on communities in Asia, Africa and Latin America.” (Puckett, 2019). Similar words are spoken by practitioners across the range of environmental and social problems.

There is now an historic opportunity for ecological economics research to inform plastics and recycling policy. This includes reducing both production and consumption. The need is for policy at the scale of households, nations, and in the next Basel Convention annex or agreement. Plastics policy is needed on every continent and for every ocean. If ecological economists partner with practitioners who deeply understand this issue, and if ecological economics research can be provided in a timely, effective form, with the capacity for rapid scaling, practitioners can implement policy widely. The Basel Action Network and Break Free From Plastics (BFFP) group have goals in clear alignment with ecological economics. BFFP is a large global network of NGOs that could disseminate and implement ecological economics policy that is supportive of their goals. The Global Coordinator, Von Hernandez, winner of the Goldman Environmental Prize, has attended many Basel Convention meetings. I've known Von for 25 years. He and other staff at BFFP have spent years participating in the Basel Convention and working with everyone from local communities to national governments, from the waste pickers in Manila, to the customs office in China. They understand the opportunities and hazards of the issue. For example, the solution BFFP proposes, of halting the production and use of plastic, is countered by some with proposals to incinerate plastic waste on a tremendous scale. However, incineration is not a just or economic solution. As BFFP and the Global Alliance for Incinerator Alternatives have well documented, the human health damages from incineration are significant and disproportionately born by the poor and people in Asia, Africa and Latin America (GAIA, 2019).

These practitioners have prepared the ground for large-scale change. Ecological economics research can speed the process. How much plastic is too much plastic? BFFP has a goal of peak plastic production by 2025 and the elimination of non-essential plastic usage by 2035. This includes ten cornerstone principles (BFFP, 2019). The first is: *“Our lifestyles and economy fit within the environmental limits of the planet.”* A more succinct ecological economics goal has seldom been stated by ecological economists. The organization also emphasizes environmental justice.

The full list of ten principles/goals includes:

1. Our lifestyles and economy fit within the environmental limits of

the planet.
2. Waste is reduced, first and foremost.
3. Material lifecycles are responsible.
4. Community action and partnerships.
5. Support for waste pickers and recyclers in the transition to safer ecologically sound materials.
6. Producer responsibility for the full lifecycle costs and impacts of products.
7. Reduce and reuse for essential plastics with removal of toxic substances.
8. Waste to energy is not the solution due to pollutants and greenhouse gas emissions.
9. Organic waste is a solution.
10. Materials systems should slow climate change and not accelerate it.

The network has over 1500 member organizations. And they have gained power. BFFP worked with the Malaysian Government in stopping plastic waste, and they were present at the June G-20 meeting in Japan, where plastic waste was on the agenda and progress, though insufficient, was made. The BFFP goals are an excellent step forward for solving this crisis. Plastic is a technically tremendously complex challenge, but BFFP is cutting a path forward that is consistent with ecological economics and proving effective in the broader political and cultural spheres for galvanizing support and change with speed and at scale.

Ecological economists who have analyzed petroleum and plastics industries should be engaged with these organizations. How can ecological economics not provide key research for these organizations which largely hold an ecological economics paradigm? Talking with them, integrating our research agenda with theirs, organizing better, structuring our research appropriately, and assigning classes to solve economic problems that BAN or BFFP identify, can also help all this build the next generation of applied ecological economists.

5. Conclusion

Implementing ecological economics at scale is being accomplished in some areas, and opportunities abound. Constraints to the adoption of ecological economics, imposed by politics, culture, power structure, and neoclassical economics are I believe, weakening. Extensive experience in applying ecological economics across political divides and in the face of neoclassical economics convinces me that organizing our research into a more effective structure for providing and delivering ecological economics to, and establishing better relationships with, practitioners will vastly accelerate the implementation of ecological economics.

After many years of debate in the journal we can make some conclusions about valuation based upon experience. Whether to monetize, or not to monetize, is a question best answered in the applied context, not in theory. In allocating billions of dollars for restoring the Mississippi River Delta, politics, culture, and law determine that valuation is essential to implementing needed and costly infrastructure change at scale. Valuation of ecosystem services in restoring the Mississippi River Delta will continue to be essential to achieving restoration at scale.

Valuation is not required for some very significant policy changes, even at the global level. The Basel Convention adoption of the ban on hazardous waste shipments to non-OECD countries did not require valuation of damages. Ratification took over twenty years. Had there been valuation, could the ratification of the Basel Ban by the required number of nations have been accelerated? I don't know. Research into when valuation is effective is needed.

The plastics crisis is vast in scale, and tremendously complex in production and consumption. This issue is more difficult than either the Basel Ban, or deltaic restoration. Grappling with the plastics crisis locally and globally will certainly require both valuation and non-valuation approaches.

Two examples, deltaic restoration and the plastics crisis provide examples of how there is ample space for implementing ecological economics, and many journal articles attest to the fact that our opportunities for implementation are wide open.

Change at the scale and pace needed requires not only research, but dynamic research that is proactive and can be rapidly reactive. Success in applying ecological economics requires good research readily available to practitioners. One raging debate in our field, within climate change, and other areas, is that of the more radical and effective solutions vs. politically and socially acceptable solutions. The latter is generally considered watered down and often ineffective. In our 2014 book on Mississippi Delta restoration (Day et al., 2014) we provide a much more comprehensive delta restoration solution, for example utilizing a century of sediment build up behind dams in the basin to double the river's sediment load (also reducing flooding upstream). That has not yet been adopted due to complex politics. Yet, I have concluded that this is somewhat of a false debate. Whether actions are sufficient at scale to solve the tremendous problems we are faced with is an essential and valid question. We need solutions at scale that are truth-tested in physical reality. Greenhouse gases, like ozone depleting gases, need to be reduced in the atmosphere. That all solutions must pass through the gauntlet of politics, society, and culture is reality as much as atmospheric greenhouse gas concentrations. We do ourselves no favor as ecological economists in achieving implementation by moaning about the fact that the best solutions have not been implemented. Plunging into the political, social, and cultural complexity to implement change is just as essential to achieving our goals as theoretically figuring out economic policy solutions. Often, our “best solution” is not the best solution because it cannot be implemented. Political and cultural openings do occur which enable even better solutions, if we are prepared and can engage quickly and effectively with those opportunities and the communities pursuing them.

The more we engage in successfully applying ecological economics, the more attractive our field is to decision makers, the public, students, faculty and practitioners. Their participation in real problems helps alleviate our capacity shortage. It is wonderful to see the commitment and work of ecological economists. We need rigor and consistency. We need application and implementation. We often must act with the tools and research available when opportunities to implement ecological economics arise.

Ecological Economics, the Journal has been essential to our progress. The next thirty years of journal publication would be even more effective by organizing research and tools to fit with the broad goals of successfully applying ecological economics. This requires closer collaboration with practitioners. Some practitioners are applying ecological economics without much knowledge of it and would be more effective with closer collaboration and greater knowledge. Conversely, the journal and academic community would be enriched by better collaboration and understanding how change is actually made. This collaboration can help drive scaling forward.

Our challenges are great. Ecological economics cannot solve the world's multiple crises alone, however, ecological economics is likely an essential ingredient for realizing solutions. Thus, our focus for the next thirty years of research should be on careful research, integrating transdisciplinary experience for students, on organizing research and data in forms that practitioners can use, and decision makers can understand, all to implement the transformation that our economy requires.

In this next thirty years, let's continue advancing the journal and bring the implementation of ecological economics to scale!

A note of thanks

This academic field improves people's lives. I am an example of that. I thank everyone who has taken the time to write, critique, review, and

edit research in ecological economics. Thirty years of publishing research represents a great deal of excellent work by our community, and it's been invaluable to me. Yet it is generally people that bring people into a field, not journals.

In 1984 while working as a geologist in the 5th largest U.S. coal mine (Centralia, Washington), I called Herman Daly, *and he answered the phone.* I told Herman that I had read his books, wanted to study with him at LSU in the economics graduate program and confessed that I had taken just one class in economics. *He encouraged me to take undergraduate micro and macro and then apply.* That discussion with Herman was transformative for me. Let's answer our phones, respond to the email, and recruit students who may not seem to fit the program.

Just over 30 years later, my transformation from the coal mine to applied ecological economics has been through academic study and research on a plethora of topics and represents the possibilities we have and the tremendous need for our field. But social transformation at scale can only happen with an open and energetic, well organized, useful research program with outputs that are well structured for applications.

Acknowledging the legacy of Herman Daly, Bob Costanza and all those who have contributed to the journal they founded means recognizing that our ranks require exponential growth. Foremost in our research program should be teaching, mentoring, funding, expanding, employing, diversifying, and growing the numbers of ecological economists. Secondly, mentoring and training ecological economists in actually *applying* ecological economics should be built into every undergraduate and graduate program. Aggressively promoting the diversification of our ranks and of our partnerships is essential to live the justice we preach, and pragmatically implementing a positive agenda that responds with pragmatic solutions to current crises and opportunities can result in successful economic transformation. We need to ensure ecological economics is encouraging to, and shaped by, non-traditional students, and to the full diversity of humanity, to achieve a research agenda with the breadth and depth needed and reflective of current problems, solutions, communities and opportunities.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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