Land-Grant Lessons for Anthropocene Universities

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ABSTRACT: Established amidst the bloodshed of the Civil War, land-grant universities, together with the associated agricultural experiment stations and cooperative extension services, have played a crucial role in democratizing scientific knowledge and addressing intertwined educational, environmental, economic, and democratic challenges within the United States. Indeed, they have arguably pioneered the idea of 'usable science.' Today, the urgent challenges of the Anthropocene demand a more robust relationship between scientific research and on-the-ground action, strong networks sharing local lessons globally, and channels for injecting global, long-term perspectives into the noise of short-termism. The land-grant experience provides lessons for 'Anthropocene universities' seeking to tackle these challenges, including the importance of: (1) establishing or expanding university-based boundary organizations akin to cooperative extension, (2) incentivizing the integration of engagement into the university's research, teaching, and service missions, (3) centering values of democracy, justice, equity, and inclusion in engagement, and (4) cooperating across institutions and sectors. Given the urgency of fully engaging academic institutions as players and connectors in the real-world challenges of addressing climate change and biodiversity loss, there is little time to waste.

Keywords: Land-grant universities, higher education, extension, Anthropocene

In 1862, amidst the bloodshed of the US Civil War, President Abraham Lincoln signed the Morrill Act, establishing the US land-grant college system. Together with the Morrill Act of 1890, the Hatch Act of 1887, and the Smith-Lever Act of 1914, this legislation transformed US higher education. These Congressional acts established a network of publicly funded universities devoted to training the next generation of farmers and engineers, conducting innovative and useful research to advance agriculture, and engaging with farmers to disseminate the fruits of this research. The land-grant universities, together with their associated agricultural experiment stations and cooperative extension services, have played crucial roles in rural development and the democratization of scientific knowledge within the United States (Gavazzi & Gee, 2018); indeed, they have arguably pioneered the idea of 'usable science' (Kopp et al., 2019). The land-grant experience provides insights into how to leverage higher-education institutions to address problems with intertwined educational, environmental, economic, and democratic facets. Today, these land-grant lessons can inform a crucially important, global mission: driving usable Earth system science that links researchers and educators to communities and decision makers, in order to enable society to tackle one of the greatest challenges of our century — humankind's new role as an increasingly self-aware, planetary force.

Usable Earth system science needs for the Anthropocene

Over the course of the last two centuries, humankind has become one of the principal drivers of many of the central processes of our planetary home: from climate and ecological change to sedimentation and the nitrogen cycle. Increasing recognition of this role – and of the footprints this role is leaving in the geological record – has led to a recent effort by the International Commission on Stratigraphy to formally identify a new geological epoch, the Anthropocene (Zalasiewicz et al., 2011). As yet unclear, however, is whether the Anthropocene will be a short-lived blip in the geological record – a thin temporal horizon as the bright light of civilization briefly blazes and then extinguishes itself – or a long new era of self-aware planetary stewardship, what some have dubbed the "good Anthropocene" (Bennett et al., 2016). Drawing on the lessons of the land-grant model, higher-education institutions can play a crucial role in tilting the scales toward the good Anthropocene.

The planetary challenges of the Anthropocene all involve complex systems that require the intertwined perspectives of multiple traditional scientific disciplines to understand. It is impossible to understand the future of Earth's climate, for example, without insights from geology, oceanography, atmospheric science, ecology, economics, sociology, and political science, among other disciplines. The last four decades have therefore seen the emergence of Earth system science, which aims to understand how the different elements of the Earth system interact and behave as a whole. And while Earth system science originally focused primarily on the Earth's biogeophysical subsystems, the 21st century has seen a growing emphasis on more comprehensive integration of human processes (Steffen et al., 2020).

But the planetary challenges of the Anthropocene are too profound – indeed, in some cases, existential – to wait for ivory-tower academics to develop a comprehensive understanding of complex planetary systems before science is translated into action. While assessments and syntheses, such as those of the Intergovernmental Panel on Climate Change (IPCC), have long been a key tool within Earth system science (Steffen et al., 2020), on their own, they form a relative narrow and slow channel of communication between the research community and global publics.

The recognition of the urgent need for scientific knowledge to inform action related to complex, coupled natural-human systems has led to the development of transdisciplinary science (Hadorn et al., 2008). Transdisciplinary approaches to system science go beyond interdisciplinarity by recognizing stakeholders outside of academia as critical partners throughout the research process. Transdisciplinary research may be focused either primarily on expanding fundamental insight or on applying existing understanding; in either case, the ultimate use of the research – the real-world problem the research is trying to solve – is a guide-star throughout. (The concept of 'convergence research,' promoted by the US National Science Foundation, is essentially a charismatic renaming of this concept (National Research Council, 2014), and both concepts fit within the umbrella of 'Public Impact Research' (Association of Public & Land-Grant Universities, 2019).)

True transdisciplinarity is hard – it requires a considerable investment on the part of researchers or their institutions in maintaining strong, working, trusting relationships with stakeholders. And building such relationships is slow – if it must be done from scratch, it does not sit well with the incentives or time pressures faced by pre-tenure faculty or graduate students. Moreover, just and equitable transdisciplinary science requires deliberate efforts to engage historically marginalized populations, not simply those most ready to build partnerships – a task which requires further investment of time, money, and expertise.

The necessity of sustained relationships lasting beyond individual projects leads to a critical role for boundary organizations that have long-term relationships with and therefore accountability to both researchers and stakeholders (Cash et al., 2003; Guston, 2001). Such boundary organizations create spaces for the groups to interact iteratively over boundary objects that are meaningful to all parties involved. Researcher-stakeholder interactions, mediated by skilled professionals, help ensure that co-produced science is viewed as credible, legitimate, salient – and therefore usable – by stakeholders (Cash et al., 2003; Sarkki et al., 2015).

The tripartite land-grant mission

Although the language of 'transdisciplinarity' is relatively new, its practice has long been central to the land-grant mission. The land-grant model rests on three pillars: instruction, represented in the agricultural college vision of the Morrill Acts; research, represented in the agricultural experiment stations and the Hatch Act, and extension, represented by the cooperative extension system and the Smith-Lever Act. The Hatch Act established agricultural experiment stations at land-grant institutions to both conduct original research and "aid in acquiring and diffusing among the people of the United States useful and practical information" (Ferleger, 1990).

Expanding the educational mission of the experiment stations, the Smith-Lever Act established cooperative extension services, jointly funded by federal and state governments, with the aim of bringing scientific knowledge about agriculture and home economics out of the universities and into the country. Over the past century, extension services have placed agents in almost every US county and built networks of trust that link the land-grant institutions to the (primarily rural) community. These extension agents, land-grant faculty who are scientifically trained and embedded in their local communities, work closely with extension specialists, based at the land-grant institution, who lead research and education programs and serve as bridges between other land-grant faculty and the extension agents (Brugger & Crimmins, 2015). Many other faculty in the agricultural schools of land-grant universities are also partially supported through cooperative extension or experiment station funds, expanding the pool of researchers involved.

While the three land-grant pillars map onto the tripartite mission of instruction, research, and service common to all modern research universities, they are all tinted by an externally focused, democratizing, and use-inspired mission, and all receive federal and state funding at an institutional level to support this mission. Though this mission can sometimes be obscured in twenty-first century land-grant universities, which in the face of an environment of declining government support for public higher education have often come to resemble other research universities, in the land-grant ideal it is at the heart of the university. Integrating research, instruction, and action is not a novel "Fourth Purpose" (Bollinger, 2019); it cross-cuts and integrates the three traditional purposes of research universities.

Cooperative extension services serve as boundary organizations that facilitate the integration of university scholarship and real-world problem solving. Cash (2001) highlights the way this has worked to advance water management in Kansas and Nebraska. There, cooperative extension helps "negotiate the boundary between science and decision making," while "exist[ing] between two distinct social worlds with definite responsibility and accountability to both sides of the boundary." It also serves to coordinate across scales, bringing university researchers and extension specialists together with federal, state, and local actors to address a challenge that spans the three-state region hosting the Ogallala Aquifer.

The engagement enabled by cooperative extension strengthens the ability of the university to undertake usable research by enhancing the credibility, relevance, and legitimacy of the research through iterative researcher-stakeholder interactions (Cash, 2001; Sarkki et al., 2015). As McDowell (2003) writes:

> [S]ynergistic power derives from scholarship practiced where tests of workability and relevance are institutionalized—the power of engagement. Further synergy is generated when access to the knowledge is ensured for users who will find it useful in their lives. Some of the power from engagement and access to knowledge is intellectual by virtue of the contribution to both the quality and relevance of the science practiced. Other power is political, resulting from the engagement with users of the knowledge, the access they have to the scholarly product, and the usefulness of the new knowledge to them.

More than a century of sustained federal and state funding for the land-grant enterprise provides one qualitative indicator of the model's success (McDowell, 2003). Economically, the US agricultural knowledge and information system as a whole, of which the land-grant universities are key components, has historically had a rate of return on investment of about 20-40% (Alston & Pardey, 1996; McDowell, 2003). Econometric analysis finds that the initial designation of the land-grant colleges led to about 45% increases in population density and 60% increases in manufacturing productivity over the ensuing eighty years (Liu, 2015). Such quantitative economic metrics, however, address just a narrow slice of the land-grant mission; as Liberty Hyde Bailey, the founding dean of the New York State College of Agriculture at Cornell University, wrote in a 1907 address (quoted in Peters, 2006a):

> While the College of Agriculture is concerned directly with increasing the producing power of land, its activities cannot be limited narrowly to this field. It must stand broadly for rural civilization…. The task before the colleges of agriculture is nothing less than to direct and to aid in developing the entire rural civilization; and this task places them within the realm of statesmanship.

Further complicating evaluation of the land-grant enterprise is the limited attention given to its most unique element, that of cooperative extension. Nonetheless, as McDowell (2003) writes, "The extension function is certainly a necessary if not sufficient condition to system success, and extension's influence on the research agenda may go a long way in explaining the high productivity of the system."

The democratic mode of cooperative extension

Throughout its history, cooperative extension has exhibited two modes of operation, corresponding to two alternative narratives and one counter-narrative about the role of the university in the agricultural knowledge system (Peters, 2006b, 2008). In the technocratic mode, extension is a conduit by which the scholars at the land-grant university provide knowledge to extension's largely agricultural clients. In the associated 'heroic' narrative, described by Peters (2006b),

> [F]armers are beset by technical problems they cannot understand, let alone solve. A scientific expert comes to the rescue. He or she diagnoses the technical problems, develops solutions (in the form of new knowledge and/or technologies), and applies them. The problems are solved, agricultural efficiency and productivity are improved, and the material interests of everyone are simultaneously advanced.

The technocratic mode is reflected in Bailey (1893)'s early view that the "office of universities is primarily a mission to the people." It sees land-grant researchers as missionaries, bringing the fruits of science to the farmer, and aligns closely with the flawed 'deficit model' of science communication (Cook & Overpeck, 2019).

This technocratic missionary mode has spurred a populist counter-narrative in which the land-grant universities, by helping drive agricultural modernization, fostered "technocratic colonization and environmental destruction", promoting a "rural society organized almost entirely by a managerial elite" (Peters, 2006a). Indeed, as control of the agricultural system in the US has increasingly fallen into the hands of a corporate managerial elite, the land-grant system has become more aligned with that elite. McDowell (2003) concluded that "describing the system as being held hostage by agricultural interest groups [was] considered a fair characterization of the relationship between Land-Grant extension and the agricultural client groups at the beginning of the twenty-first century." Market pressures have also pushed the land-grant universities in that direction, for instance encouraging the patenting and licensing of innovations, such as new crop varieties, once developed as public goods (Collins, 2015). Indeed, as McDowell (2003) notes:

> For many academics, the exposure to real-world problems comes through consulting activities rather than through public service. Indeed, consulting, like public service, makes a positive contribution to scholarship through both the test of workability and the test of relevance. However, understanding the direction in which the flow of benefits is moving and not to confuse this benefit from consulting with public service is important. Similar observations can be made about the corporatization of the university. While the corporate owner provides real-world input (and funding) to the scholarly agenda, it is a far cry from an institutionalized test of scholarly relevance, where relevance is measured in societal terms. In the current scramble for funding support for higher education from corporate business, the danger is that university administrators will confuse usefulness to corporate America with usefulness to the society.

A further element of this counter-narrative notes the ways the land-grant system has supported settler colonialism and racist hierarchies. The land that was granted to fund the institution was taken from dispossessed American Indians (Nash, 2019). In addition, until the 1970s, the historically Black 1890 land-grant institutions, established as 'separate-but-equal' institutions in former Confederate and border states, were subordinated in federal extension support to their (historically white) 1862 land-grant institution counterparts (Comer et al., 2006).

Alongside these original inequities, however, a democratic mode of extension and an associated liberatory narrative is also deeply rooted in land-grant history. The democratic mode, "compels and authorizes scholars to establish reciprocal relationships between the university and the public that hold both democratic and academic promise" (Peters, 2008). In Bailey's later view, engagement "needed to take the form of a democratic association that is deeply educative" (Peters, 2006b) and advances "real democratic expression on the part of the people" (Bailey, 1915). This view is likewise represented in a 1930 assessment of the US agricultural extension system (Smith & Wilson, 1930; quoted in Peters, 2002) (emphasis added):

> There is a new leaven at work in rural America. It is stimulating to better endeavor in farming and home making, bringing rural people together in groups for social intercourse and study, solving community and neighborhood problems, fostering better relations and common endeavor between town and country, bringing recreation, debate, pageantry, the drama and art into the rural community, developing cooperation and enriching the life and broadening the vision of rural men and women. This new leaven is the cooperative extension work of the state

> agricultural colleges and the federal Department of Agriculture, which is being carried on *in cooperation with the counties and rural people throughout the United States.*

This democratic mode, with its emphasis on sustained stakeholder cooperation, is consistent with modern best practices for transdisciplinary engagement.

Universities as scale-crossing institutions

The traditional land-grant mission focuses on the problems of each institution's home state, and within each state, the institutions have built strong networks of trust. As Cash (2001) notes, regional cross-scale coordination, for instance within a watershed, has also been part of land-grant practice. The need for regional coordination was also recognized by the early leaders of the land-grant system. For example, Kenyon Butterfield, then president of the Massachusetts Agricultural College (now the University of Massachusetts Amherst), urged the development of a New England-wide agricultural federation that included the region's agricultural colleges and experiment stations, as well as other key stakeholders in the regional agricultural system (Butterfield, 1907).

Nested spatial scales are even more pervasive in the environmental challenges of the Anthropocene: global change creates local difficulties and opportunities; conversely, local changes, accumulating to global scale, create global threats and opportunities. The sea-level rise that threatens coastal communities arises from the global accumulation of greenhouse gas pollution, while leaky natural gas distributions systems in areas with dated infrastructure can drive a substantial portion of national methane emissions. Conversely, innovative local models for advancing adaptation and mitigation can provide globally transferable lessons.

Universities are natural bridges across spatial scales. As a core part of their work, university-based scholars share knowledge through globally read journals and international professional societies. They are often active in international research collaborations. Their service mission encompasses participation in national institutions such as the National Academies and global institutions such as the IPCC and the International Union for the Conservation of Nature. In these regards, scholars at public and land-grant universities differ crucially from other public servants, for whom participation in such venues is at best a secondary or tertiary priority, and who may experience difficulty getting funding or authorization for activities outside their core geographic domain.

At their best, universities are also natural bridges across temporal scales. In much of the private and public sector, short-term perspectives are dominant. Publicly traded corporations are often driven by the 'tyranny of quarterly earnings' (Carey et al., 2018), while political leadership in democratic countries often suffers from the 'not-in-my-term-of-office' (NIMTOF) perspective (Kunreuther, 2006). Across society, the consistently increasing pace and noise of the news cycle also makes it more difficult to take the long-term perspective.

Universities, by contrast, are inherently cross-generational institutions. Today's faculty are training undergraduates who will have careers that run through the 2060s and lives that will run through the 2080s. Doing so well requires that students be equipped to analyze the complex set of human and natural systems that will reshape the planet over their lives. This mission provides some countervailing force against the ever-present pressure to focus instead on preparing students for the jobs of the 2020s, and echoes Bailey's exhortation that the agricultural college's education be "fundamental in character, of such a nature that it interests the listener in the subject because of its intellectual relish, and thereby sets him *[sic]* to thinking" (Bailey, 1896; quoted in Peters, 2006b).

Indeed, the intertwining nature of universities' educational, research and service missions means that government investments in transdisciplinary research at universities can also serve as an investment in the rising generation. This contrasts with government expenditures on private-sector consulting studies and research, which may return immediately usable knowledge but generally neither advance fundamental understanding nor provide educational benefits, with returns being captured by corporate shareholders rather than the general public.

Moreover, the crucial traditions of tenure and academic freedom – both still fairly strong though also under significant pressure – enable academic scholars to voice longer-term perspectives that may be unpopular or unremunerative in the short-term. This, too, provides a key contrast between scholars at public universities and other public servants, as well as between scholars and private consultants.

Further, universities are themselves long-lived institutions. Most of the US land-grant institutions originated in the nineteenth century and are likely to continue into the twenty-second. With appropriate career incentives for the participating scholars, they thus provide natural homes for the long-term observation systems needed to track regional and global environmental change and understand these changes. Through enduring relationships with host jurisdictions and communities, they can feed emergent knowledge into decision-making processes and thus play a key role in long-term adaptive environmental strategies, such as flexible adaptation pathways (Haasnoot et al., 2019; Rosenzweig & Solecki, 2014).

Paths forward

Many land-grant universities have extended the cooperative research and extension concept beyond agriculture and rural development. At Rutgers, for example, the experiment station hosts programs that help coastal communities increase their resilience to storm and sea-level rise (e.g., Lathrop et al., 2014). Outside the formal experiment station and extension service, Rutgers staff have built partnerships, such as the New Jersey Climate Change Alliance, that link communities, NGOs, and businesses to university climate science expertise (Kaplan et al., 2018). Building off these partnerships, Rutgers now hosts the New Jersey Climate Change Resource Center, which has a statutory mission to leverage the state's academic institutions to "create and support the use of impartial and actionable science to advance government, public, private, and nongovernmental sector efforts to adapt to, and mitigate, a changing climate" (New Jersey Climate Change Resource Center, 2020). Similar examples at other land-grant institutions include the Pennsylvania State University's Center for Climate Risk Management (e.g., Sriver et al., 2018), the University of Arizona's Center for Climate Adaptation Science and Solutions, and the University of Connecticut's Connecticut Institute for Resilience & Climate Adaptation. Other large public research universities are building transdisciplinary efforts with significant extension components, such as the University of Washington's EarthLab and Scripps Institution of Oceanography's Center for Climate Change Impacts and Adaptation.

Unlike the core agricultural work of the Smith-Lever Act's cooperative extension, however, many of the extended extension missions are sustained in large part by strength of personality or by relatively short-term sponsored projects. They lack the multidecadal stability of traditional cooperative extension, which limits their potential – particularly in the Anthropocene context, where the crucial planetary challenges differ from the classical agricultural extension challenges in spatial and temporal scales. The urgent challenges of the Anthropocene demand a more robust relationship between scientific research and on-the-ground action, strong networks sharing local lessons globally, and a channel for injecting global, long-term perspectives into the noise of short-termism. These needs call for Anthropocene universities — including but not necessarily limited to traditional land-grant institutions — that adopt a re-envisioned land-grant mission.

First, Anthropocene universities should support engagement through long-lived, university-based boundary organizations, like cooperative extension. Sustained engagement in transdisciplinary research and education requires shifting the maintenance of stakeholder networks that extend beyond cooperative extension's traditional agricultural networks away from individual investigators and sponsored projects and to the institution (Gee et al., 2019). Transdisciplinary research will never reach its full potential if stakeholder networks must be built anew when investigators leave an institution or grants end. It will also be hampered if stakeholders suffer fatigue after being repeatedly engaged by different, but uncoordinated, researchers eager to put the transdisciplinary approach into practice. Usable Earth system science calls for sustained, coordinated, and substantial investment in internal boundary organizations – extension, broadly conceived. Such investments may come most readily at land-grant universities and other public universities that already have an extension tradition, but can be adopted by other schools as well.

Second, Anthropocene universities should not view engagement focused on solving the challenges of the Anthropocene as an add-on to the university's research, teaching, and service missions. It should instead be integral to these missions, much as engagement has infused the missions of the agricultural colleges, experiment stations, and extension services. Anthropocene universities should seek opportunities to encourage and remove barriers to such integration.

For example, the current tenure process at most land-grant and research universities increasingly prioritizes research above all else and measures success by metrics such as citations and external grant funding. Transdisciplinary research is inherently slower than more ivory-tower research, requiring that researchers invest time in engaging stakeholders in the research process. Especially if coordinated as part of an institutional extension network, this engagement can contribute substantially to the success of the institution in linking science and action. For this reason, land-grant institutions often apply more engagement-focused scholarship criteria to extension faculty (e.g., Wise et al., 2002). More flexible tenure evaluation processes that recognize the value of engagement and apply more broadly than extension faculty can help advance engagement at Anthropocene universities (Association of Public & Land-Grant Universities, 2019).

Anthropocene universities should also invest more heavily in undergraduate and graduate education that links science to action and provides the systems-level perspective that equips students to cope with the planetary changes they will experience over their lives. Project-based courses that bring students into contact with stakeholders and help stakeholders solve real-world challenges are an approach that works well in some professional education programs – think of law school clinics, public policy workshops, or urban planning studios – and are ripe for expanded implementation in the environmental arena (e.g., Ferraro et al., 2020). Many of the students who receive such education may later become leaders of stakeholder organizations with whom the university partners.

Third, Anthropocene university-based boundary organizations and the researchers who work with them must be cognizant of how their activities interact with existing power structures and should center values of democracy, justice, equity, and inclusion. Anthropocene universities should be receptive listeners and facilitators, avoiding the failings of the technocratic, missionary mode of extension, the ‘information deficit’ model of science communication, and the populist counter-narrative they can inspire. They should also seek to address inequities that underlie current strengths. For the land-grant universities, for example, more equal partnerships between the 1862 land grants and the historically Black 1890 land grants, as well as with the tribal colleges and universities that were given land-grant status in 1994, could help redress past wrongs.

Fourth, Anthropocene universities should play close attention as to how they fit into and can cooperate with the broader set of organizations working to solve Anthropocene problems. Butterfield (1907) called upon land-grant colleges, experiment stations, and extension to cooperate with a broader ecosystem of agencies addressing the problem of rural development, which included primary and secondary schools, the farm press, the country churches, and the cooperative farmers' organization known as the Grange. Butterfield's perspective highlights the importance of universities examining their own role as players in the broader ecosystem of institutions addressing the challenges of the Anthropocene and partnering with organizations, like the Grange, that represent populations affected by Earth system risks. Universities with different types of stakeholder networks – for instance, state research universities, historically black colleges and universities, tribal colleges, and global elite universities – can all play complementary roles in addressing Anthropocene challenges, and will be most effective if they cooperate in a manner that leverages their different strengths and relationships. Doing so while centering justice, equity, and inclusion requires a degree of institutional humility that scales with a university's level of resources.

Understanding how best to make the Anthropocene university work is itself a research project, and it will require funding from governments and private donors willing to experiment. While the Morrill Act of 1862 brought the land-grant model to national scale, it built on the model of the Agricultural College of the State of Michigan (today's Michigan State University), established seven years earlier. Likewise, the 1914 Smith-Lever Act built upon the extension experience of Cornell University's New York State College of Agriculture, established in 1904. The federal/state co-funding model of the land-grant system, which allows the details of institutional structures to reflect the conditions of different states, facilitates such experimentation and could serve as a model for federal investment. Initial federal seed grants to states, for example, could allow states the flexibility to leverage their higher-education institutions in a manner that reflects their distinctive circumstances while helping spur the establishment of a national Cooperative Climate Research, Education and Extension Service.

Given the urgency of fully engaging academic institutions as players and connectors in the real-world challenges of addressing climate change and biodiversity loss, there is little time to waste.

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