Science with Practice on a Three-Legged Stool

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Our conference topic is *Surviving and Anticipating Waves of Change in Public Research Universities*. There are a multitude of approaches to surviving change, and probably an equal number of approaches to **anticipating** those changes. There are the changes we are already experiencing, like demographic cliffs, accelerating climate change, and dwindling state support for public research universities. There are changes we can imagine are coming, like AI-based tutors that teach more effectively than a disengaged instructor, or hybrid/virtual face-to-face degree programs that are shorter and lower cost to students. Then there are black swan events that are beyond the imagination; the obvious example being the global pandemic we are slow-burning through.

I am going to argue today that the uncertainties inherent in our situation mean that success or failure will be driven more by **principles and culture** than by strategy and planning, and I'll suggest some principles to consider.

This meeting matters, because public research institutions improve the lives of people far beyond what most people recognize. To that end, I'll begin with two semi-quantitative stories: The first is about land grant institutions, the second about my home department in particular.

The land grant mission is the "three-legged stool" to which this talk's title refers. As you are all likely aware, these three legs are:

(1) Extend knowledge to practitioners in the state (and beyond) – this is Extension.

(2) Create new knowledge – this is Research.

(3) Educate the people in a wide variety of subjects, including agriculture and the mechanical arts – this is Education (typically residential education).

To try to grasp the impact of these institutions, consider just one area of instruction – engineering. Prior to the establishment of the land grants, there were barely a half-dozen departments offering degrees in engineering (Reynolds, 1992). Less than two decades later, there were over 80 such departments (Reynolds, 1992).[1] This explosion of opportunity, combined with strong demand for engineers, increased the number of engineers in the U.S. by two orders of magnitude from 1850 to 1910. The mind boggles at how that growth of technical know-how impacted the trajectory of U.S. history through the 20th century.

The second quantitative story is about my home department of Agricultural and Biosystems Engineering (ABE). That department serves all three parts of the land-grant mission. Furthermore, ISU's motto of *Science with Practice* informs our departmental efforts, because working with stakeholders (e.g., downstream communities, various ag industries, farmers) forces us to address the practical implications of the science and engineering that we do. There are many problems faced by agriculture that have simple solutions—if you ignore the vagaries of economics, technological lock-in, peer pressure, and so on. *Science with Practice*

[1] Reynolds is in a line of revisionists who argue that the impact of land grants on engineering is overstated. I am skeptical of their argument but recognize my lack of scholarly expertise in this realm.

is a reminder that while theory may be beautiful and insightful, it alone cannot make changes in the world. It's also a reminder that while common sense and hard work are valuable, they are not substitutes for the scientific method as a way of understanding the material world. Instead, it's the union of the two – *Science **with** Practice* – that is extraordinarily powerful and world-changing. (And, just to be sure that you don't think of me as a complete techno-optimist, I am well aware that the many world-changing impacts of science and technology have had multiple unintended consequences.)

Back to my department: We have active extension programming in six major areas, ranging from farm safety to water quality, from grain processing to machinery systems. We are research active, with annual research expenditures expanding from about $8 million to $13 million over the last decade. We have four accredited undergraduate degrees – two in technology, two in engineering, as well as graduate degree programs in both technology and engineering.

In 2014, we moved into a new $74 million lab/office complex on the west side of ISU's campus. I served as associate chair for teaching from 2011to 2016, so during the move, as our enrollment was climbing through 700 undergraduates, and I felt simultaneously ecstatic at the wonderful new facility, and yet terribly guilty about it.

Yes, guilty. Such an amazing building, reflecting a $74 million expenditure, with $60 million from the taxpayers of the state, and the remaining $14 million from donors. How could this be justified?

To try to answer this question, I ran some numbers, pertinent to our undergraduate teaching programs, as follow.

Across the four undergraduate programs, we were graduating approximately 140 students per year at the time. The **net present value** of the average income increase of one student (i.e., compared to what they could have made with a high school diploma) was somewhere between $500,000 and $900,000 depending on the assumptions about time in workforce and discount rate. Taking the more conservative number, the net present value of the degrees granted each year – just to the degree holders – was on the order of $70 million. That's a conservative estimate because salary is normally considerably lower than value added to the economy.

For this talk, I took a step further, and made a rough estimate of the research impact. I found that in 2019, Deleidi et al., at University College London, estimated the GDP multiplier of non-military R&D as 7.7x (Deleidi et al., 2019). They arrived at that value by examining quarterly historical data from 1947 to 2017 in the U.S. That means that a single $10 million annual research expenditure might have GDP impacts on the order of the building's cost.

For extension, things are harder. As a first approximation, examining the programs of two of my colleagues who work in animal waste management and animal environmental systems, numbers on the order of $1 million to -$25 million per year are found based on conservative assumptions related to increased nutrient use efficiency or disease prevention.

Combining these numbers from all three legs of the stool results in an estimated impact on the order of $150-$175 million per year; making the state's investment in our building far more reasonable.

Forgive me for quoting numbers at you; hopefully they are relevant to making the case for public funding of our institutions. And – and this is a big caveat – **I recognize the terrible danger in making it all about money.**

The impacts we have on people's lives through our extension, research, and teaching **transcend dollars.** Furthermore, **only valuing what's measurable** is a lousy way to run an enterprise – as many formerly great companies can tell you.

For these reasons, I am unapologetically of two mindsets:

(1) We have to quantify the economic impacts of our institutions because they're generally far higher than perceived, and we deserve to be funded (and to have accessible tuition for students). It's a given that spending on college athletics is not questioned, because brand recognition, local economic development, etc. It needs to become a given that high-quality research/extension/teaching is a similar boon to the state and nation.

(2) In our day-to-day extension, research, and teaching efforts, we cannot just be bean counters! We need to do good science and publish in high-quality journals, but it's not just "number of papers" or h-index that reflect the quality of scholarly output. We need to have accredited degree programs and to deliver programs that attract reasonable numbers of students, yet it's not just accreditation or student-credit hours generated, or fundamentals-of-engineering exam pass rates that reflect teaching quality. There are ineffable qualities that determine the greatness of our efforts: the degree to which we actually inspire and engage students, our thoughtfulness in handling a question from a farmer, an insight into how to approach a scientific problem that arises from a conversation with a grad student. Furthermore, those non-measurable qualities—the care we give all students, the decency with which we treat each other, and the integrity with which we conduct our research—are the strongest bulwarks against losing support for these institutions.

One last point: Some of you may know that RAGBRAI is a 50-plus-year-old mass bike ride across Iowa. Call it a rolling festival of bad '70s rock (I sometimes do), a 15,000-person COVID-super-spreader event (as a friend of mine described it last year), an opportunity to roll across the Iowa countryside without worrying about distracted drivers (a rant I'll spare you), or an oddly Iowa mode of providing an economic boost to small towns. Regardless, it is an important thread in Iowa's cultural fabric. I've done it thrice, and each time, while stopped at small towns or rest areas, I met people who knew colleagues of mine or who had had classes with me. It drove home to me that my adopted state – and many of yours – is not that big a place. People know how the extension faculty member responded (or not) to their question; they hear about their family member's experience in first-year engineering, or physics, or agronomy; and they form critical impressions about the institution on this basis, which amplifies the case for using both strategy **and heart** to navigate the uncertainties of the future.

Let me summarize (and extend) what I've learned trying to do *Science with Practice* on a three-legged stool: Numbers matter, but they're not the only thing. A culture of integrity, excellence, and kindness is as important as a strategy to be more competitive (or should be a core part of such a strategy).

I think a fair critique of what I've just said is that it's platitudes: "This person made me sit for 15 minutes to tell me everyone should be nice!" This audience is disproportionately leaders, and we have more control over the culture in our spheres of influence than we may recognize. The way I, as a faculty member, treat my undergraduates and graduate students tells them something about expectations and possibility. The same is true for the way chairs and deans treat faculty members, and so on. Recognizing that culture exists, and that it is not equally welcoming to all members of our community, and being intentional about making a program, department, college, or unit more welcoming is worthwhile. Recognizing that teaching and research are deeply complementary, not oppositional, and finding ways of promoting that synergy is worthwhile. These are efforts we are uniquely positioned to engage in, and I hope that in so doing, we strengthen our institutions and amplify the positive impacts we can make.

References

Deleidi, M., De Lipsis, V., Mazzucato, M., Ryan-Collins, J., & Agnolucci, P. (2019). The macroeconomic impact of government innovation policies: A quantitative assessment. *UCL Institute for Innovation and Public Purpose, Policy Report (IIPP 2019-06)*. https://www.ucl.ac.uk/bartlett/public-purpose/wp2019-06

Reynolds, Terry S. (1992). The Education of Engineers in America before the Morrill Act of 1862. *History of Education Quarterly* Winter, 1992, Vol. 32, No. 4, pp. 459-482. Cambridge University Press. Stable URL: https://www.jstor.org/stable/368959

RegenPGC

The RegenPGC[2] project (https://www.regenpgc.org/) seeks to perennialize working lands, thereby improving soil conservation and water quality while maintaining or increasing profitability, enhancing biomass production, and improving overall system resilience. Below are two references to recent review papers about this approach published by members of our team.

Schlautman, B., Bartel, C. A., Diaz-Garcia, L., Fei, S., Flynn, E. S., Haramoto, E. R., Moore, K. J., & Raman, D. R. (2021). Perennial groundcovers: an emerging technology for soil conservation and the sustainable intensification of agriculture. *Emerging Topics in Life Sciences* 5(2): 337 – 347. https://dx.doi.org/10.1042/etls20200318

Moore, K. J., Anex, R. P., Elobeid, A. E., Fei, S., Flora, C. B., Goggi, A. S., Jacobs, K. L., Jha, P., Kaleita, A. L., Karlen, D. L., Laird, D. A., Lessen, A. W., Lübberstedt, T., McDaniel, M. D., Raman, D. R., & Weyers, S. L. (2019). Regenerating agricultural landscapes with perennial groundcover for intensive crop production. *Agronomy* 9(8): 458. https://doi.org/10.3390/agronomy9080458

[2] Regenerating America's Working Landscapes to Enhance Natural Resources and Public Goods through Perennial Groundcover (PGC)

Project Overview

Zero-competition agriculture (ZCA) dominates our region for multiple reasons – simple, high-yielding, reliable, scalable

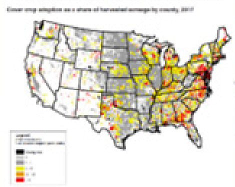
But there are serious downsides!

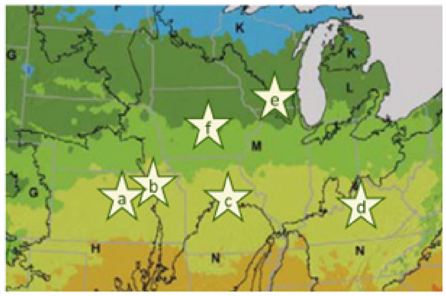
Cover crops reduce the long periods of bare-soil associated with ZCA, but deployment rates are low

Why? – Likely a combination of tangible ($) and intangible (complexity) costs

Can we simplify cover cropping while perennializing the landscape?

*We believe so, and this is the core of the **RegenPGC** vision!*





Key Collaborator Locations (Major Land Resource Areas)
a – The Land Institute (H)
b – Kansas State (H/M)
c – Univ. of Missouri (M/N)
d – Univ. of Kentucky (N)
e – Univ. of Wisconsin (M/K)
f – Corteva Agriscience / Iowa State Univ. (M)

H – Central Great Plains Winter Wheat and Range Region
K - Northern Lake States Forest and Forage Region
M – Central Feed Grains and Livestock Region
N – East and Central Farming and Forest Region

REGENPGC

Quad Chart: RegenPGC

Timeline and Funding:

Start and End Dates: *9/15/21 – 9/15/26 (5 yr)*

Funding amount: *$9.99M*

USDA Award #: *2021-68012-35923*

Key Near-term Milestones:

Research: Establish best management practices for Gen-1 PGC systems; generate enterprise-level budget impacts (w/ risk distributions) of Gen-1 PGC

Extension: Support multiple on-farm trials through multi-modal extension programming, and highlight findings (+/-) at field days

Education: Train first two cohorts of RET/REU pairings

Collaborators:

Research: *Brandon Schlautman, The Land Institute*

Extension: *Daniel Andersen, Iowa State University*

Education: *Kenneth Moore, Iowa State University*

Commercialization: *Sara Lira, Corteva Agriscience*

Admin (Deputy Dir.): *Anne Kinzel, Iowa State University*

End of Project Outcomes:

Significant increase in US cropland acres with year-round groundcover – **target 5% of Iowa by PY5**

Decrease in soil erosion from corn and soybean cropland in the US corn belt

Decrease cropland nitrogen and phosphorus exports

REGENPGC