

Agricultural Research Today for a Better Future Tomorrow

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Scientia

AGRICULTURAL RESEARCH TODAY FOR A BETTER FUTURE TOMORROW

How to support the expanding human population is one of the greatest societal challenges in the 21st century. To meet the demand for food, fuel and fibre, agricultural productivity will need to dramatically increase. However, to ensure long-term sustainability and resilience, increased productivity must not sacrifice the health of the surrounding ecosystems. Led by Dr Dennis Busch and Dr Andrew Cartmill, the University of Wisconsin-Platteville's Agro-Ecosystem Research Program draws on the expertise of local and international collaborating scientists and farmers to develop alternative agricultural practices that support sustainable intensification for future food security.

Sustainable Agricultural Intensification

The rapidly expanding human population is estimated to reach 9 billion by the year 2050. That's 1.5 billion more mouths to feed in just 30 years, on a planet with resources that are already overstretched. To meet these demands, agriculture will not merely have to maintain current levels of productivity – it will have to greatly exceed current levels. It is expected that by 2050, over 80% of agricultural production will come from land that is currently cultivated.

Conventional agricultural intensification, which has allowed us to increase yields to current levels over the last few decades, is frequently associated with practices that degrade the environment. These practices, such as increasing application of chemical fertilisers, may help to increase yields over the short-term, but they are much like borrowing from tomorrow to pay for today.

Conventional intensive farming leads to the degradation of 'ecosystem services' – such as natural pest control and productive soils – eventually meaning that maintaining the same yields is impossible, no matter how much extra fertiliser is added to the system.

Climate change, increased urbanisation, environmental degradation, and increased municipal and industrial competition for finite resources place additional pressure on agricultural systems, threatening their long-term sustainability and resilience.

To intensify agriculture in a sustainable way, alternative practices that support healthy ecosystems are vital. Taking care of the 'agro-ecosystem' – the farm and surrounding natural habitats – requires holistic approaches.

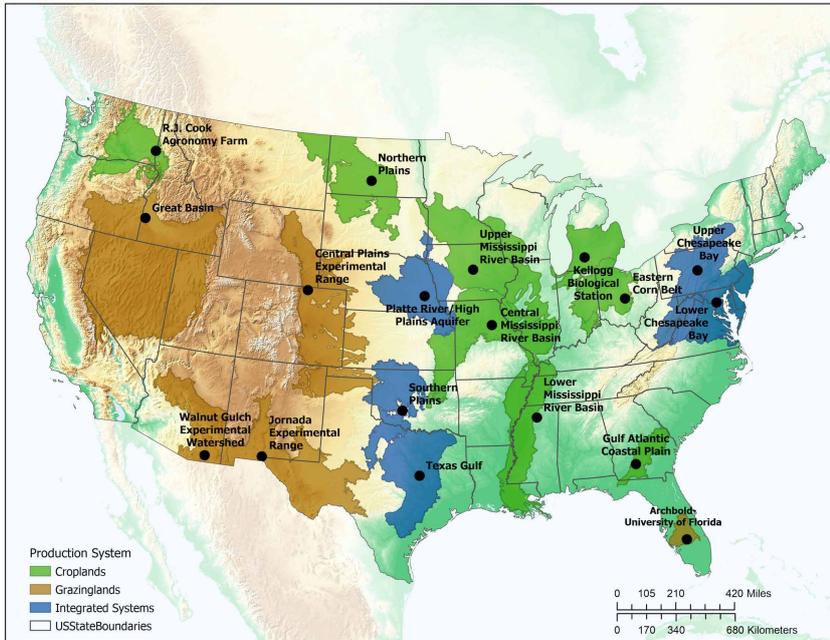
'Agroecology, which is the study of farming within a system, is understanding that farming is not separate from the landscape. It's "big picture" thinking. It's relating everything back together. Not just the fertiliser, not just the yield, but also how your plants or your farm adds value back to the landscape,' explains Dr Andrew Cartmill of the University of Wisconsin-Platteville (UW-Platteville).

Dr Dennis Busch and Dr Cartmill have been investigating which alternative agricultural practices offer whole system improvements to agro-ecosystem health. In their Agro-Ecosystem Research Program, Dr Busch and Dr Cartmill have been collaborating with local, national, and international farming groups and scientists to gather



the evidence needed to develop farming Best Management Practices.

The program consists of multiple projects – funded by a variety of external agencies, including the USDA's National Institute of Food and Agriculture – addressing important research areas, such as reducing and eliminating water contamination and greenhouse gas emissions from farms in the US Midwest, investigating how cattle grazing can play a role in sustainable agricultural practices, and exploring how farms with equipment to monitor environmental health ('instrumented farms') can supply the evidence needed to sustainably intensify agriculture.



The LTAR network comprises 18 locations distributed across the US working together to address national and local agricultural priorities and advance sustainable agricultural intensification.

Collecting the Evidence

The research team, students, and collaborating partners measure numerous environmental health indicators to assess the effect that different agricultural practices have on the surrounding ecosystems.

For example, the use of ‘cover crops’, which involves cultivating plants in between growth cycles of food crops, can improve soil nutrient levels, enhance the amount of carbon sequestered and stored in soil, reduce soil erosion, and improve water cycling. However, choosing which cover crops to use, when to plant them, when to harvest, and what practices to use alongside the chosen cover cropping method are decisions that require reliable evidence about their impact on the agro-ecosystem.

The overarching aim of UW-Platteville’s Agro-Ecosystem Research Program is to work towards achieving the ‘three pillars’ of sustainability– environmental, economic, and social – to ensure the resilience of agricultural communities and our future food security. To achieve this goal, the program draws on the expertise of a multidisciplinary team and focuses on three core areas – research, outreach, and education.

It’s All about Networking

By collaborating with farming networks, the Agro-Ecosystem Research Program accesses a stream of high-quality primary data from instrumented farms that underpins the information-driven approach of the projects. ‘This approach will also allow for the assessment of the reaction of local farmers to future scenarios, create buy in, mediate iterative discussion and provide a unique multi-facet approach to educate students in real world applied farming issues,’ says Dr Busch.

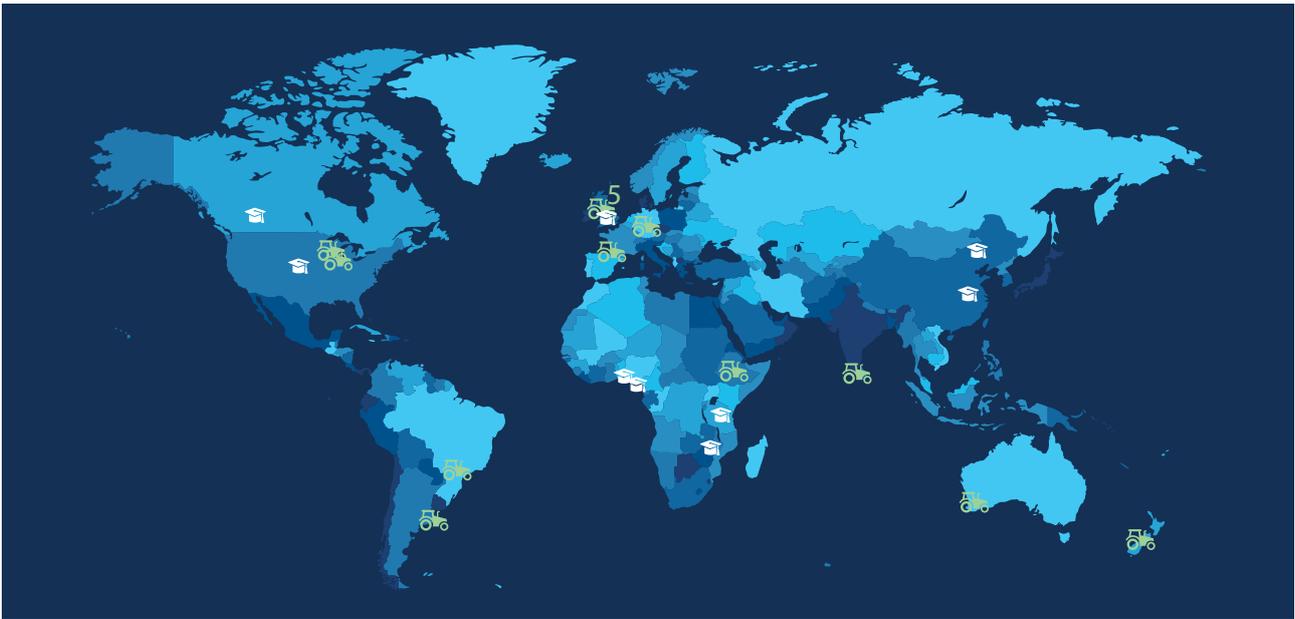
Locally, the team has partnered with research farms that facilitate plot-level experiments, allowing them to investigate multiple or ‘risky’ practices before expanding promising methods

to field-scale trials. The team has also formed partnerships with the Soil and Water Health Coalition, Illinois, and the Lafayette Ag-Stewardship Alliance, Wisconsin – both farmer-led non-profit organisations committed to sustainable agriculture and resource conservation. Across the regional and continental scale, the USDA Long Term Agroecosystem Research network includes 18 research units strategically located across the US focused on addressing questions of sustainability and resilience in agricultural systems. This collaboration allows the researchers to engage in synergistic, nationwide research activities.

Internationally, the Global Farm Platform network provides eight strategically-placed farm platforms, including the UW-Platteville Pioneer Research Farm, dedicated to the sustainable intensification of grazing livestock production. This has provided the Agro-Ecosystem Research Program team with access to a global academic network to support research and education. These farm platforms are located in the US, South America, the United Kingdom, India, Australia, and New Zealand.

Quantifying the effects of different agricultural practices takes the guesswork out of selecting the most appropriate methods to support sustainable production. Combining environmental measurements with those of economic performance, such as crop yields or livestock growth and weight, helps the researchers find the right balance that ensures future economic viability and food security. Dr Busch and Dr Cartmill have devised research projects that address urgent and important local and regional needs. ‘While global issues of long-term food availability and security are driving forces in developing national policy and research priorities, it is the regional and local environmental issues that have been the primary impetus for action among the local farming community,’ explains Dr Cartmill.

‘The issues of concern voiced by our collaborating farmer-led groups include elevated nitrate concentration in groundwater, soil loss from cropland, and nitrogen loading to the Gulf of Mexico,’ he continues. Excess nitrogen from chemical fertiliser usage leaches from farmlands into the surrounding



Farm platforms and academic partners involved in the program.

waterways, causing a deadly low-oxygen zone that makes coastal habitats hostile to marine life.

A report in 2018 estimated that 70% of the nitrogen and phosphorous in the Gulf of Mexico originates from agricultural sources, which reaches the gulf via the Mississippi River. Wisconsin, Illinois and Iowa are particularly susceptible to contributing excess nutrients to groundwater and waterways due to the naturally shallow depth of the soils in these regions.

The multidisciplinary Agro-Ecosystem Research Program team – which incorporates natural scientists, engineers, social scientists, and economists – aims to find practical solutions to eliminate water contamination from farms in the Midwest states. In time, these techniques could be extrapolated to farms across the rest of the US and the world.

Education and Outreach

As part of the program's educational objectives, undergraduate students on UW-Platteville's agricultural courses participate in field data collection and laboratory analysis while designing and developing their own real-world research under the guidance of Dr Cartmill, Dr Busch and their team.

With access to local, national, and international partners, students can undertake short-term research experiences from locations across the globe, giving them a fantastic opportunity to align their work with their individual interests. Students improve their communication skills, gain leadership experience, enhance their critical thinking, and improve their ability to synthesise information through these experiences.

Developing sustainable and productive agricultural practices is an ongoing process, unlikely to provide all the solutions overnight, training a qualified and skilled workforce that

can continue this research in the decades to come is vitally important. In addition to UW-Platteville's established courses and modules, such as Crop Science and Weed Science, the Agro-Ecosystem Research Program is providing the scope for the team to develop a dedicated Freshwater University.

UW-Platteville is ideally situated for freshwater research and training, and the Freshwater University will coalesce the strength, diversity, and collective resources of the University of Wisconsin System. Dr Busch and Dr Cartmill have been generating real-world, hands-on datasets through the Agro-Ecosystem Research Program that will form the basis of the existing and new courses to be included in the Freshwater University syllabus.

The farms used to evaluate alternative agricultural practices also serve as an engagement tool. A key component of the Agro-Ecosystem Research Program is effective and productive outreach activities. The three pillars of sustainability – environmental, economic, and social – rely on largescale uptake of alternative agricultural practices by farmers. Thus, increasing the reach of the program could positively influence perception and subsequent uptake of these methods.

Results obtained from the demonstration plots are included at field days, meetings, and newsletters. For example, in a recent field day in Jo Daviess County, Illinois – hosted virtually due to COVID-19 – researchers, crop advisors, and students covered topics including the value of cover crops, results and plot details from nitrogen research, and soil health and water quality results from the demonstration plot.

By incorporating education and outreach activities alongside the research, the Agro-Ecosystem Research Program has the potential to affect real change by starting a global agricultural revolution – one farm at a time.



Meet the researchers

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Dr Dennis L. Busch holds the position of Research Director at UW-Platteville Pioneer Farm, managing research projects related to dairy pasture forage, surface water runoff, and also devoting time to supervising student researchers. A Wisconsin native, he achieved his undergraduate BS in agricultural business and MS degree in agricultural industries from UW-Platteville, and earned his PhD in water resources science from the University of Minnesota-Twin Cities. Dr Busch teaches undergraduate modules in Agricultural Hydrology, Water Quality, and Agroecosystem Research.

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Dr Andrew D. Cartmill earned his PhD in horticulture from Texas A&M University, before continuing his research at Texas A&M and at the University of Wisconsin-Platteville. Within the latter's Department of Soil and Crop Science, he currently holds the position of Assistant Professor. Dr Cartmill's research interests focus on sustainable agriculture and ecological topics, including crop and fungal mycorrhiza associations, plant responses to environmental stress, water quality, and plant nutrition. In addition to his research activities, Dr Cartmill teaches across a range of undergraduate modules in UW-Platteville's School of Agriculture, including Crop Production and Agroecology.

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