To begin, can you outline the key objectives of the Forever Green Initiative (FGI)?

The FGI aims to support sustainable intensification of agriculture in Midwest USA. To do this we are integrating new or improved fallow season and perennial crops into agricultural landscapes. These crops can increase production by expanding growing seasons and improving use of water, nutrients and solar energy, while also providing many other ecosystem services. Additionally, they can produce a wide array of high-value bio-based products and materials, as well as sustainably produced biofuels. In this way, these crops create a strong ‘market pull’ for sustainable intensification – a force that is presently generally lacking.

To integrate these new and improved crops into current agriculture, and to integrate products of these crops into the expanding bioeconomy, we are coordinating innovation on three fronts: germplasm development, agroecosystem design, and development of end uses, supply chains and markets.

The FGI is large and multifaceted, what positions do you hold within the group and what are your responsibilities?

We work to coordinate the FGI, so that it serves as a coherent project for sustainable intensification, and as a learning environment for graduate students interested in innovation and sustainable development in agriculture. We support each of the 12 overarching projects in the FGI portfolio, assisting in fundraising and in relationships with stakeholders.

The holistic approach of the FGI aims to unite policy makers, rural communities and businesses. Why is fostering such collaboration so important and how have you been able to satisfy the motivations of such diverse parties?

Addressing the key motivations of a wide range of participants in the FGI is an ongoing challenge. We have used state-of-the-art methods for supporting deliberation and foresight in multistakeholder groups, and can claim some successes in helping interested parties recognise ‘win-win’ opportunities being created by the work of the FGI. These parties are now beginning to work together to scale up cultivation of the new crops that the FGI is developing and commercialising.

What are some of the current barriers to extending the growing season faced by farmers?

There are many biophysical, sociocultural, economic and policy impediments. The growing season itself is limited in the north temperate zone by physical factors. However, more important is that the genetic quality of these crops and the agroecosystems in which they must function – as well as the supply chains and end-use markets that enable profitable production – are all underdeveloped. Through a coordinated programme, the FGI is working to address these barriers.

How have your academic and professional backgrounds prepared you for this work?

Throughout our careers, we have focused on the development of diversified farming systems. We have strived to coordinate biophysical and social research on these systems, because both are critical to the development and commercialisation of diversified farming. We have also maintained extensive two-way partnerships with stakeholders who can contribute resources and knowledge needed to develop diversified farming systems that are viable in social, economic and environmental contexts.

Does the Initiative’s systemic approach have the potential to be adapted for other states or regions?

Systemic and comprehensive approaches to sustainable intensification are prerequisites in
Researchers involved in the Minnesota-based Forever Green Initiative are developing and commercialising a portfolio of perennial and winter annual crops to incorporate into the existing agricultural landscape, making intensive agriculture more sustainable and economically efficient.

**INTENSIVE AGRICULTURE HAS** rarely been seen as a sustainable practice. Despite being pivotal for the global production of food, farmlands dominated by a narrow variety of monocultures have caused significant environmental problems. However, with the worldwide population expected to reach 9 billion by 2050, the demand for food and agricultural resources will continue to grow and put pressure on farmers to further intensify practices. Therefore, developing farming systems that can offset the environmental costs associated with increasing productivity is paramount.

**LAND OF 10,000 LAKES... AND FARMS**

In Minnesota, nearly half the countryside is dominated by farmland for the cultivation of popular crops such as corn and soybean. Most of these current varieties are ‘summer annuals’, harvested in late summer and autumn and leaving the land barren until they re-establish themselves in June. This lack of soil coverage renders the landscape more vulnerable to soil erosion, fertiliser run-off and nutrient loss. The absence of profitable alternatives means farmers are reluctant to switch to winter annual and perennial crops, so this gap in annual soil coverage is left unfilled.

Recognising this, Professors Donald Wyse and Nicholas Jordan of the Department of Agronomy and Plant Genetics within the University of Minnesota, USA, have been working for nearly two decades on developing and commercialising new alternative crops to make the farmlands of Minnesota and surrounding regions more productive, economically efficient and environmentally sustainable.

**BUILDING THE BIOECONOMY**

Their project – the Forever Green Initiative (FGI) – aims to expand the growing season by adding selectively bred winter annual and perennial crops to the existing agricultural landscape. These new varieties offer a greater range of food, feed and biomaterial products than those of traditional farming systems, and the development of these new commodities can support the expansion of new industries and increase employment opportunities. Alongside this, the greater crop diversity will also protect the system against climatic variability – predicted to increase in forthcoming years – as well as enhancing soil and water quality, and promoting biodiversity.

The progress achieved by the FGI has been made possible, in part, by recent advances in genomic sciences. “These novel technologies are driving a new era in plant breeding in which unprecedented rates of genetic progress are expected. Genomic science has greatly increased the pace and decreased the cost of germplasm development, and so rapid and relatively inexpensive genetic improvements in these crops are now highly feasible,” explains Wyse.

A central tenet of the FGI is to tackle the economic barriers that have previously hampered success in incentivising farmers to plant perennial and cover crops. By developing novel breeding programmes, the researchers can make genetic improvements to crops so they are more viable for commercial exploitation. Then, to ensure successful integration of winter annuals and perennial crops to the existing landscape, they are developing novel strategies for engaging a wide range of stakeholders in designing new agroecosystems that include these crops. Finally, to make use of the new materials being produced from the diversified farming systems, the commercialisation of products is being promoted by public and private sector initiatives to create bio-based products, via active incubators for commercialisation called ‘Landlabs’.

**GREENER ALTERNATIVES**

Developed by the FGI team, Landlabs build on the existing outreach and engagement capacities of the University of Minnesota to coordinate investments in new agricultural enterprises and develop effective strategies.
for commercialisation. These extensive efforts form the basis of the FGI.

For their Perennial Sunflower project, the FGI has been working since 2001 on a breeding strategy to produce a perennial sunflower hybrid. Current sunflower varieties can be used to produce trans fat-free vegetable oils, but like all summer annual crops they only provide living ground cover for a short period of the year. “Benefits of the perennial crop include soil protection, reduced nutrient leakage and better tolerance of droughts and floods that are predicted to become more common in the years ahead,” Wyse elucidates. By 2025, the team hopes to expand the marketplace and produce a perennial crop that is as productive as current varieties.

FUTURE OUTLOOK
The Perennial Sunflower project is just one of many examples in which an FGI project is precipitating a paradigm shift in the way modern agriculture is perceived. By utilising crops that are productive for the majority of the year, FGI researchers are merging the benefits of both intensive and sustainable agriculture. In addition, the benefits to farmers are clear: new crop options that improve conservation of soil, water and biodiversity, and the opening up of new industries and economic opportunities.

These new production systems bring not only myriad environmental benefits, but also enhance the economies of rural communities. As the FGI moves forward, breeding programmes and agronomic research will be expanded upon and advanced end-use and supply-chain information for alternative crops will be developed.

CASE STUDIES

PERENNIAL FLAXSEED
Perennial flaxseed is a winter annual crop being studied intensively at the University of Minnesota. As an excellent source of omega-3 fatty acids and widely used as a dietary supplement, it is a good example of a natural plant material being produced from Minnesota’s native perennials. However, the research needed to develop these native plant resources for use in natural preservatives and cosmetics is still incomplete. Therefore, the University of Minnesota is partnering with Aveda, a Minnesota cosmetics company, in the hope of pooling resources to bring these potentially highly profitable products to market.

INTERMEDIATE WHEATGRASS
Being similar to conventional bread wheat, intermediate wheatgrass has been the subject of advanced breeding at the University since 2010, working to improve the size, yield and quality of the seed, as well as flavour and nutrient composition. Improvements in these traits would make the crop more suitable for use by food companies and has already generated interest from the food retailers General Mills and Patagonia. It also serves a second purpose: it is capable of being grown on abandoned agricultural land to sustainably produce biofuels. With consumer interest driving a market pull for products from sustainable resources, further R&D of these commercially exploitable traits will make perennial crops a more attractive option for Minnesotan farmers.

HAZELNUTS
The University is also working on establishing a new hazelnut industry in Minnesota with the potential to not only benefit individual farmers but also bring employment opportunities back to small towns and diversify rural economies. American and European species of hazelnuts are being hybridised to combine fungal disease resistance and tolerance to extreme weather with commercially desirable yield and quality nuts. High in heart-healthy monounsaturated fatty acids, vitamin E, thiamine and fibre, hazelnuts can be pressed into oils for culinary and cosmetic applications. Challenges to date have been maintaining consistency in nut characteristics. Future research requires long-term funding to further develop commercially viable methods of clonal propagation as well as ways to harvest and process high yields.