GROWING FOOD IN A FINITE WORLD

Case studies of The Nature Conservancy's key agriculture solutions

Smarter Agriculture Practices

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Smarter Agriculture Practices

Experts agree that world food production will need to massively increase by 2050. But such production cannot be achieved by doubling land or water use—quite simply, there is not enough of either. Agriculture must get smarter, using land more productively and water more efficiently if we are to reconcile the need for growth with the need to preserve all of our natural resources, safeguard natural habitats and keep the climate in safe boundaries.

At The Nature Conservancy, we know we cannot achieve mission success without addressing unsustainable agricultural practices, whether in the fields where crops are produced, in the forests where agriculture is in encroaching, or on the rangelands where animals graze. These case studies offer an overview of five strategies we are working on: sustainable intensification, precision agriculture, decision support systems, climate smart agriculture, and eliminating deforestation from commodity supply chains. While not all-encompassing, these case studies provide an overview of our thinking and of the types of projects we invest in.

Ours is an ambitious vision—to achieve our objectives, tens of millions of farmers across the world need to change their behaviors. But by targeting our work in the right places and influencing the right set of public and private institutions, we are moving from the theory to the practice of change, ensuring we can feed a growing population while maintaining a balance between development and conservation.

Stanley, fruit and vegetable farmer on his farm in the Upper Tana Watershed, Kenya. Photo credit: © Nick Hall

Case Studies:

CLIMATE SMART AGRICULTURE »

DECISION SUPPORT SYSTEMS »

ELIMINATING DEFORESTATION FROM COMMODITY SUPPLY CHAINS »

PRECISION AGRICULTURE »

SUSTAINABLE INTENSIFICATION »

Global Agriculture Climate Smart Agriculture

A Kenyan woman picking tea on a tea plantation in the Upper Tana Watershed, Kenya. © TNC

Of all the risks facing the world food system, climate change is the greatest. Rising populations and growing demand also present challenges, but humans have historically been good at improving agricultural technology when they have to, and increasing input as required. Climate change is a different and a more dangerous type of threat: it is challenging our ability to respond with technology alone.

Threats linked to climate change come in different shapes and forms. As weather patterns change, farmers and ranchers need to adapt to shifting crop and livestock footprints: what once grew or grazed somewhere may have to move. Weather variability will also increase, although farmers are used to coping with variable weather.

The most worrying risk is that climate change will cancel out any increases in agricultural productivity or advances in agricultural technology in two ways:

- hitting yields – there is already some evidence of that with maize and wheat;
- reducing land available for food production, through flooding associated with rising sea levels, increased salinity in river deltas, and, most worrying of all, desertification – as areas become dryer, topsoil erodes more easily.

The only way to respond is by developing climate smart agriculture, which has two dimensions. One is to mitigate or lessen: reducing agriculture's contribution to climate change. The other is to adapt: reducing the impact of climate change on agriculture by making it more resilient. There is also a catch: all this has to be done while increasing agricultural production, to keep pace with rising demand.

REDUCING THE IMPACT OF AGRICULTURE ON CLIMATE CHANGE

Agriculture is itself an important driver of climate change, responsible for about a quarter of global greenhouse gas emissions through deforestation and habitat conversion, livestock, soil carbon loss, and fertilizer use. TNC is working around the world to reduce agriculture's impacts:

- helping companies and governments to eliminate deforestation along commodity supply chains, such as soy and beef in Brazil and palm oil in Indonesia;

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- working with farmers in the corn-belt in the United States, helping to reduce fertilizer use with no impact on yields and using better management practices;
- researching the potential impact of precision agriculture, reducing excess and waste in the use of all agricultural inputs;
- working with farmers and ranchers in the US, Africa and Latin America on improved soil health and increasing the organic content in soils, which can have important mitigation benefits.

In addition, our innovative decision support systems help reduce the amount of land converted to agriculture to the minimum necessary, which minimizes greenhouse gas emissions.

REDUCING THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE

TNC is working around the world to make agricultural systems more resilient and help farmers adapt to climate change:

- in the US, we are looking at how to use our extensive network of hundreds of TNC-owned farms and ranches for research to help farmers and ranchers improve land management practices;
- in Africa, we are working with local communities and government agencies in Kenya, Tanzania and Zambia to help small farmers and ranchers diversify production systems and maintain pasture quality in semi-arid environments; and
- in South America, we are helping ranchers in Colombia and elsewhere to develop integrated production systems that combine grazing with crop production and forestry and which are much more resilient in the face of changing rainfall patterns.

Children walk through burned areas along the shore of Lake Tanganyika where farmers are growing crops in the village of Nkonkwa, Tanzania. © Ami Vitale/TNC

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Global Agriculture Decision Support Systems

Santarem, Brazil – an example of successful zoning of soy plantations and forest. ©David Cleary

How do we balance the competing demands of development and conservation? One way is to use science to work out whether the demands really are competing – often they aren't. If they are, it is still important to find the best possible trade-off.

The technologies of mapping and spatial analysis are evolving very rapidly, and opening up new ways of planning land management. Food comes from landscapes divided between different land-uses – farming, ranching, conservation, restoration. The secret is to find out where maximum production can happen for the highest possible return on investment but with minimal environmental impact. Decision support systems guide planners, land managers, communities and policy-makers through that process.

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Many different end users find decision support systems useful:

- local and national governments can use decision support systems to decide where to protect land, where to restore degraded and marginal lands, and where to steer agricultural development;
- companies implementing a deforestation commitment can use decision support systems to identify where they can meet demand most responsibly from land still available for development;
- farmers and ranchers can identify degraded soils and pasture that could be recovered for production, or underperforming places where yields could be increased;
- conservation groups can identify where to reforest and restore habitat for maximum impact;
- aid agencies and rural development groups can see where it might make most sense to invest in climate smart agriculture; and
- banks and financial institutions can use decision support systems as a risk assessment tool when deciding where and how to invest.

THE EVOLUTION OF DECISION SUPPORT SYSTEMS

In the past, decision support systems got limited traction because environmental groups thought too much about the science and too little about adoption. End users beyond the environmental community were not involved in their development, so these systems did not meet real world needs. TNC insists that potential end users sit on design teams and gives them the final word in setting terms of reference for our technical teams.

We co-create the tools, ensuring their technical quality and overseeing their environmental dimension. End users – who are usually not environmentalists – need to determine the framework if the tools are to be adopted.

HOW DECISION SUPPORT SYSTEMS WORK

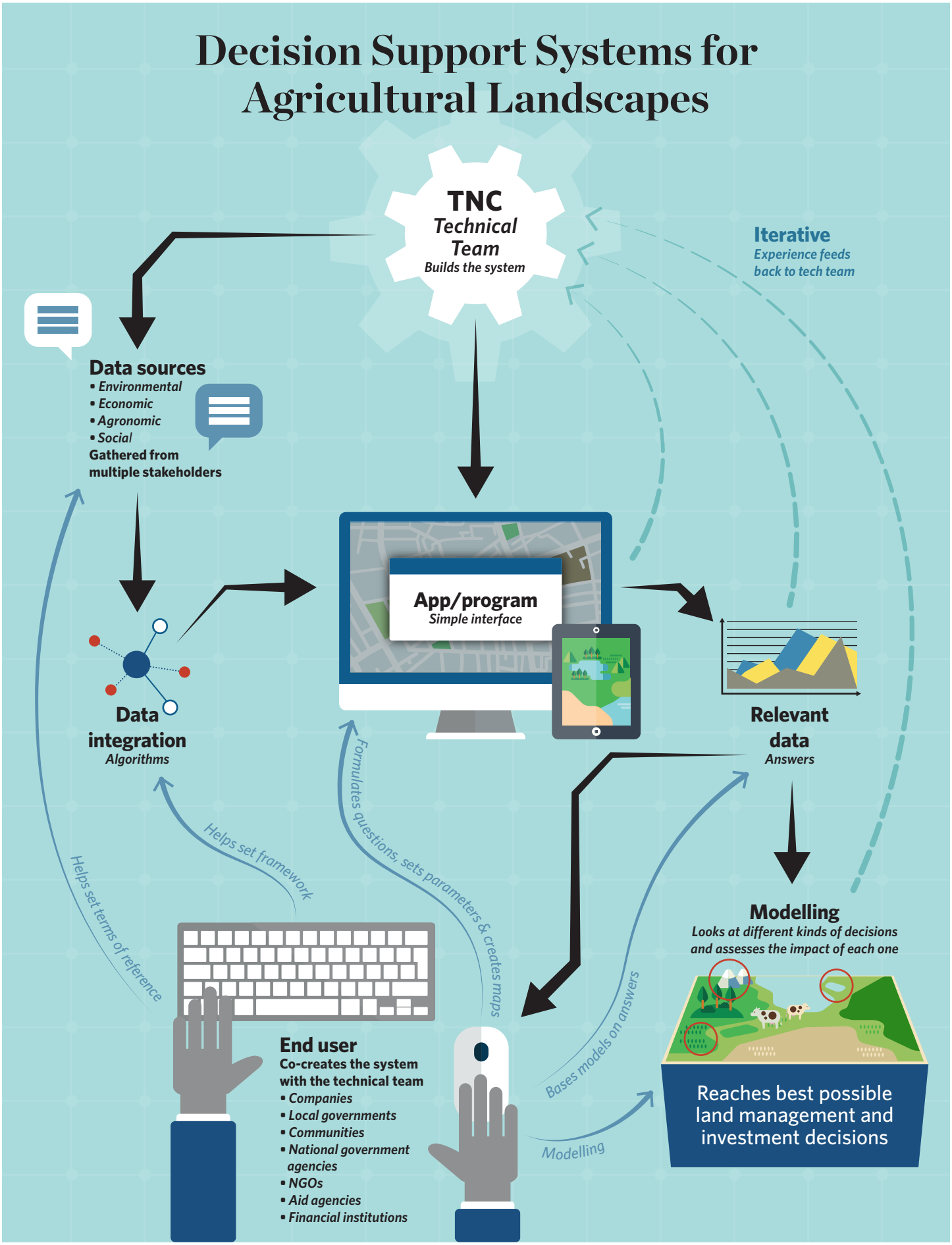
To the end user, a decision support system is a piece of technology such as an app or a program on a computer that sits behind a map. It allows users to formulate questions, set different kinds of parameters, and then use the tool to model the answer to questions they might want to pose about the future of the area, zooming in or out – depending on what scale is needed – from local community to nation state.

The system is designed to be easy to use, and assumes the user is knowledgeable but not a scientist or technical expert. The interface is visually simple. However, behind it the tool works by layering many different kinds of information – environmental, economic, agronomic and social – and applying algorithms to allow users to set parameters and create their own maps. This enables them to see the implications of different kinds of decision, assess the impacts, and make the best possible land management or investment decision. Typical questions might be:

- Where can I increase yields with no expansion of the existing crop footprint?
- What natural habitat is the most important for me to preserve if I want to maintain water quality?
- Where could more intensive ranching systems be developed on land already cleared?
- Where are land tenure systems unclear and the level of land conflict high, making them risky to invest in?
- Where are environmental risks low and responsible production systems in place, making them good investment options?
- Where would be a good place to site this grain storage facility or that food processing plant, where habitat conversion would be minimal but there is plenty of potential for yield to increase?

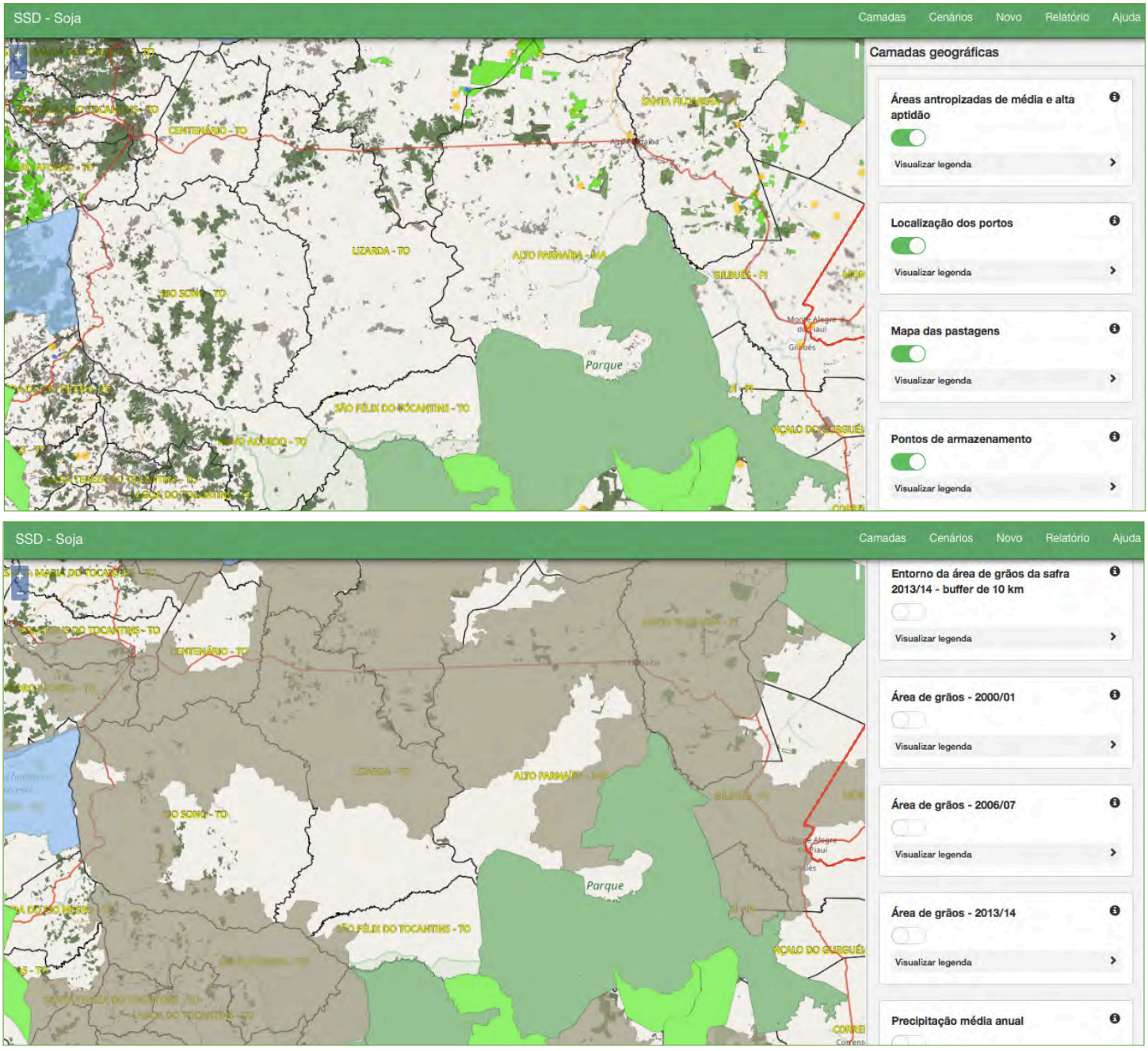
Aerial view of crop fields and farms east of the city of Foz do Iguaçu. On the right is the forested Iguaçu National Park which borders one side of the Iguaçu River in the state of Parana, Brazil. ©Scott Warren

Decision Support Systems for Agricultural Landscapes



EXAMPLES OF TNC'S WORK

- In Brazil and Paraguay, we are using decision support systems to help the soy industry implement "zero deforestation commitments" in the Amazon, Cerrado and Chaco.
- In Tanzania, we are developing decision support systems to help the Tanzanian government assess investment proposals and make land use and water management decisions in the Southern Agricultural Growth Corridor.
- In the Brazilian Cerrado, we are identifying where ranching can expand through intensification rather than converting grasslands.



Screen shot of prototype http://ssd.agrosatelite.com.br @TNC

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Global Agriculture Eliminating Deforestation from Commodity Supply Chains

Deforestation and large-scale land clearing in Mato Grosso, Brazil circa 2012 for beef production.© TNC

Agriculture drives 80% of tropical deforestation. While small farmers play a role in this, the big deforestation players are four commodity industries: beef (responsible for more deforestation than any other commodity); palm oil; soy; and the pulp and paper sectors. These four commodities account for $180 bn of the global agricultural economy. It is easy to portray agribusiness in general and these commodities in particular as deforestation villains, but the reality is more complicated.

As poverty plunges in Asia, and hundreds of millions of people globally move into higher income brackets, diets are shifting to higher protein and demand for food and consumer products is also going up. The challenge is how to meet that demand while reducing deforestation.

The good news is that it can be done. Over the last decade, deforestation in the Brazilian Amazon has fallen by over 80%, while at the same time it has become one of the major beef producing areas of the world. Hundreds of companies from the relevant commodity supply chains – more than half of pulp and paper and palm oil companies; around one-fifth of soy companies; about one in eight beef companies – have made commitments to eliminate deforestation from their supply chains completely. Many of these companies put these "zero deforestation" commitments into the 2014 UN New York Declaration on Forests. However, there is one main problem: few people know how to implement these commitments. And that is where TNC comes in.

MAKING DEFORESTATION COMMITMENTS REAL

It may sound crazy, but one major problem for companies looking to implement a deforestation commitment is that nobody can define a forest. Tropical forests like the Amazon and those in Indonesia are obviously included, but what about woodlands, dry forests and boreal forests? What about forest patches in non-forested areas? Right now, companies have no clarity about how to define deforestation, how to monitor it and how to measure progress on implementing a deforestation commitment. There is a real danger that companies, which rarely have expertise in the relevant environmental sciences and technologies, will move in different directions, using different standards, and the result will be a plethora of claims that nobody can assess. That's the kind of situation which gives bad actors cover.

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TNC is working with companies and other NGO partners to help set up the global framework that will give companies making global deforestation commitments the clarity they need. We are a driving force behind the *Accountability Framework*, a coalition of NGOs convened through the Rainforest Alliance, which is setting up a global framework for defining, measuring and monitoring deforestation. This will be rolled out in 2018. Brazil, Indonesia and Tanzania are key locations for this initiative, and we are working on the ground and with governments and companies to decrease the rate of deforestation in crucial wildlife and biodiversity hotspots. We are working directly with selected commodity traders – Cargill and Bunge for example – to help them implement their deforestation commitments across their supply chains. We are also working in the main demand centers, especially China, to educate new private sector players in emerging markets on deforestation issues and strategies to reduce deforestation in their supply chains. In the long run, even an implemented deforestation commitment, important though that is, isn't enough. It isn't a win for the climate or for conservation if we preserve forests, but destroy grasslands instead. Eliminating deforestation is not an end in itself: it is only a step on the long road to stabilizing all habitat conversion driven by agriculture.

We also need to:

- Track and monitor land-use change and habitat conversion beyond forests, especially in savannas and woodlands. The science for this has lagged behind forests, yet TNC scientists are helping to build the first large-scale non-forest monitoring systems in Brazil, Argentina and Paraguay.
- Channel agricultural expansion to low-impact areas. Any kind of conservation commitment – a compliance framework, a deforestation commitment, the creation of a Protected Area – takes land off the table for development. This immediately raises the question of how to meet demand from the land still available for development.

Conservation organizations have historically preferred to fence off places and leave it at that, but that's no longer enough. There are many places, especially in the tropics, where agriculture will expand for a long time to come. It follows that it is critical for conservation that we develop planning tools which identify "low environmental opportunity cost" areas. These are places that will give a good economic return for minimal environmental impact, for example areas with degraded soils that can be nursed back to health, pasture that could be converted to cropland without displacing beef producers, or marginal lands that could be reclaimed for production. Concentrating agriculture in these areas can relieve the pressure on more valuable habitat.

TNC scientists are working on decision support systems to help land managers, government agencies and companies around the world steer agricultural development to where it will provide maximum yields for minimal environmental impact.

Cattle ranching in Santarém, in the state of Pará, Brazil. © Claudemir Dada

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Global Agriculture Precision Agriculture

Water sampling on a TNC-owned farm in Maryland. © Tim Boucher

THE PROMISE

Agriculture is in the middle of a technological revolution that could be the most important change for farmers around the world since the Green Revolution got off the ground in the 1940s. In some ways it is predictable: information technology was bound to hit the farm sooner or later, and it is doing so in a big way. Digital technology applied to farm machinery and cloud-based information is making farming seem like science fiction in some places. Drones buzz over the landscape monitoring crop conditions and spotting problems, like pest infestations or weeds. Farmers receive personalized weather information which predicts how rainfall will vary from one field to the next. Soils are mapped at a level of precision unimaginable only a few years ago, and sensors tell farmers exactly how much water is being used at thousands of different data points. The cabins of farm machinery are filled with GPS systems and drivers no longer drive. Instead, they sit in the cabin checking screens that control the appliances, which move across fields delivering precisely measured quantities of inputs in precisely the best place, at programmed times, in perfectly straight lines or contoured to the land – whatever the data determine will give the best yield.

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All this innovation goes under the generic name of precision agriculture, and the results can be game-changing. Greater precision means water, fertilizer and other inputs can be reduced with no impact on yield. It is sustainable intensification in action: output increasing while environmental impacts, especially around water and fertilizer use, go down. That means more production, less water used, less nutrient run-off and higher water quality. In most places fertilizer run-off is the main factor behind water pollution and coastal dead zones. What's not to like?

THE PROBLEM

The issue isn't with the technologies that make up precision agriculture, but the business model behind them. When it works it is spectacular, but it only works in a few places – where farmers can pay for it. Precision agriculture is sophisticated but it doesn't come cheap. The companies that sell it recover development costs from farmers with deep pockets, who make the investment because they work on a scale that makes it economically viable. Neither is it simple to operate or to service precision technologies. Farmers need to be well educated, or depend on an extensive network of third party providers. None of this applies to where precision agriculture is actually most desperately needed – where resources and inputs are scarce, farmers are poor, and lives are on the line. How to get the benefits of precision

agriculture spread more broadly around the world is probably the most important question right now because, just maybe, the future of the world food system could depend on it.

THE URGENCY

Precision agriculture is an obvious game-changer for the industry. There is clear evidence that where precision agriculture is widely used, water and fertilizer use can go down by somewhere between 20 and 40 percent with no impact on yields, and even increases yield in some cases. Fertilizer and irrigated water expenses are reduced when less is used. Farmers who use precision agriculture do so on cost-benefit grounds.

Delivering exactly the right inputs in the right amounts at the right time in the right place could radically reduce the demand for new land by helping us operate much more efficiently on the land we already have. Increased efficiency is also central to us getting greater resilience from our food system, which it will need to endure the impacts of climate change.

WHAT TNC IS DOING

- In the Mississippi basin in the United States, in the corn and soy belt of the Upper Midwest, we are working with thousands of farmers to encourage greater precision in fertilizer application – reducing nutrient run-off as part of a large-scale program to attack the dead zone in the Gulf of Mexico.
- In the prairies of the western United States, we are working with farmers and ranchers adopting precision technology to track reductions in water and fertilizer use, and their impact on yields, and modelling what greater-scale adoption of precision technologies could mean for ecosystems.
- In East Africa – while recognizing the challenges – The Nature Conservancy is devising place- and culture-appropriate solutions that bring aspects of precision agriculture to smallholder landscapes dominated by poorer farmers and herders in Tanzania and Kenya.

Corn fields shot by a drone with a multispectral camera. © Jon Fisher/TNC

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Global Agriculture Sustainable Intensification

Irrigation efficiency project, wheat on Meaker Farm, Montrose Colorado, USA © TNC

TNC's agriculture strategy is built around the concept of "sustainable intensification". It is not a difficult idea: the world needs to increase food production but needs to do it sustainably, and the best way to do that is by intensifying production systems and keeping the geographical spread of agriculture – known in the trade as "extensification" – to a minimum. Achieving sustainable intensification is growing in urgency as we know that by around 2030 we need to get the world food system to "steady state", i.e. meeting food demand from a frozen footprint, and to minimized expansion, or very close to it. By then it's likely that there won't be much land available for expansion, at least not without unacceptable damage to biodiversity and the climate. By 2030, much of the expansion from world demand for food will already have happened. If we can get to 2030 in reasonable agricultural shape, the long-term future is good.

This may all sound very reasonable but sustainable intensification has had a rough ride as a concept. Critics have made the following undeniable points:

- Nobody can define what it actually means. There is no generally accepted "sustainably intensified" landscape you can walk around.
- There are many examples of intensification in agriculture. However, for most there are indisputable cases of *unsustainable* impacts associated with them. One example is the link between the excessive use of fertilizer in the US corn/soy belt and the dead zone in the Gulf of Mexico. Lots of self-interested actors, especially in the agribusiness industry, support "sustainable intensification", but these often focus far more on the intensification part than the sustainability part.

Yet the fact remains that there is a hard core of undeniable truth at the heart of sustainable intensification. Demand for food is increasing and will only keep increasing as billions of people in emerging markets (billions is not a misprint) move into the middle class. That demand has to be met from somewhere, and if it isn't through intensification it will be by expanding the food footprint. That would be the worst of all possible worlds, so the onus is on us to make intensification sustainable. We take the criticisms of sustainable intensification very seriously, since they are valid and deserve serious attention, and we are organizing our work in response.

FIRST, WE DEFINE IT

Agriculture is too varied for any kind of one size fits all solution; there is no single model of anything in agriculture. But we think it is possible to define general principles of sustainability *and to be able to measure them*, in any intensifying agricultural system:

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- **Healthy soils.** Good soil management is central to all agricultural success, everywhere, at all scales. Increasing organic content in soils – which doesn't only happen in organic farming – is a key sustainable intensification indicator. That is why soil health is a rapidly expanding focus of TNC's work around the world, from Kansas to Kenya.
- **Input efficiency.** Productivity and minimal environmental impact are both served by all inputs – water, nutrients, etc. – being applied as efficiently as possible, using the minimum amount necessary, in the right place at the right time. Precision agriculture (see the "Precision Agriculture" factsheet for more details) is an extreme example of this principle in action, but it applies generally across all scales of agriculture.
- **Habitat conservation.** Many farms and agricultural landscapes can benefit from the conservation of natural habitat and its integration into agricultural areas. This maintains ecosystem services upon which both farmers and nature depend: pollination; soil conservation; water quality and availability; and many more.
- **Resilience.** Farmers have always managed to weather variability but they will need to do this much more intensively as climate change bites. Crop portfolios, rotation systems, tillage systems, genetics and plant breeding, integration between cropping and livestock, and many other management practices have a role to play here.

SECONDLY, WE IMPLEMENT IT

Sustainable intensification is a cross-cutting principle that underlies all our work around the world, but the connections are clearer in some places than others.

- **Soil health** is a major focus of our work in North America and, increasingly, in Africa.
- **Input efficiency** is also central to our work on nutrient management in the US and on water quality in Latin America.
- **Habitat conservation** drives our work on eliminating deforestation from commodity supply chains in Latin America and Asia, and moving towards a complete conversion freeze in key areas like the Brazilian Cerrado by 2020 or 2025.
- **Resilience** is central to our work on climate smart agriculture in Africa. Beyond individual projects and countries, our scientists work on vital issues, like how to measure sustainable intensification once you define it, and developing tools that can move players at all scales, from farmers to governments to international organizations. We accept that there is an important minority of places where we are already at maximum carrying capacity, where an intensification approach may not be appropriate: mapping those is a key concern.

We have some early examples of what successful sustainable intensification might look like: deforestation in the Brazilian Amazon has declined by 85 percent in a decade, while its cattle herd and soy production has rapidly increased. However, the crux of the matter is that we need many more cases around the world of large landscapes increasing food production while key environmental indicators improve.

Agroforestry, Pará state, Brazil. © Henrique Manreza

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