FARMING THE FOREST STEPPE: SUSTAINABLE LAND MANAGEMENT IN WESTERN SIBERIA

Results of the SASCHA project, 2011 – 2016

SASCHA: SUSTAINABLE LAND MANAGEMENT AND ADAPTATION STRATEGIES TO CLIMATE CHANGE FOR THE WESTERN SIBERIAN GRAIN BELT

Project results 2011 – 2016

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WESTERN SIBERIA: A HOTSPOT OF GLOBAL CHANGE

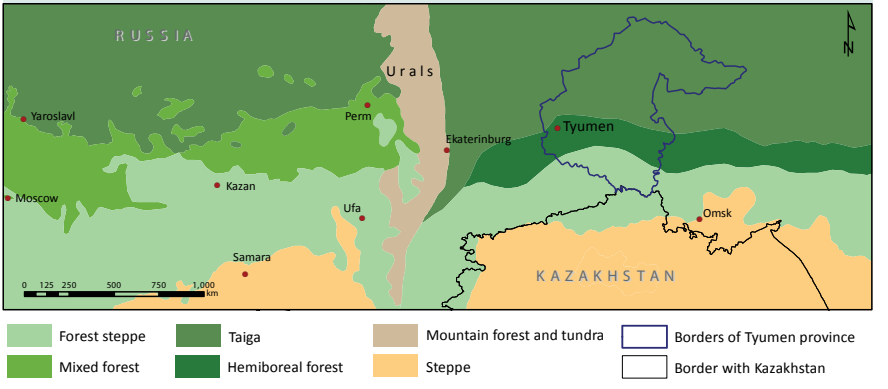
First-time visitors often expect little more from Siberia than freezing temperatures and perhaps polar bears. Of course, Siberia is much more than the European stereotypes might suggest. Stretching across several climatic zones and eco-regions, it has breath-taking landscapes, diverse peoples and culture, and even vast areas under agricultural use.

Western Siberia, situated between the Ural Mountains and the Yenisei River, is of global significance in several respects. It supplies a good deal of the world's energy through its leading role in exploiting large resources of fossil fuels – the Western Siberian gas and oil fields stretch over an area half the size of Europe. The southern parts of Western Siberia, the so-called Western Siberian grain belt, makes an important contribution to global food security: the fertile Chernozem (Black Earth) soils bear rich crops for human consumption and as livestock fodder. Western Siberia is also globally important from an environmental point of view. The soils in the area store a large proportion of the global soil carbon, especially in the mighty peat layers of the huge bogs and mires of the region, but also in the humus layers of the Black Earth soils. When carbon is released, for example by drainage or cultivation for agriculture, it turns into CO_2 and accelerates global warming. Land management in Western Siberia has thus a vital role in mitigating global climate change.

Sparsely populated, Western Siberia has also been a safe haven for biodiversity: Populations of plants and animals that are being depleted across Europe due to intensive land use and the expansion of urban conglomerations thrive here, reaching a diversity and abundance that is long gone from many Western European countries.

However, as in many other parts of the world, the tides are changing. Production and intensity of land use are increasing. People abandon the traditional villages and move to the cities. Fast growth is observed in the exploitation of natural resources. The associated infrastructure such as a new road network allows access to the last wild corners. While development is undoubtedly good news for large parts of the rural human population, it might also affect the environment – with unforeseeable consequences.

Map of the main ecozones of Eastern Europe and Western Siberia. Tyumen province is outlined blue (WWF Ecozones).



SUSTAINABLE LAND MANAGEMENT IN WESTERN SIBERIA

Concerns about 'unsustainable' developments are mounting in many regions of the world, and Western Siberia is no exception. Future land use across the Western Siberian grain belt needs to be sustainable to minimize environmental impacts. Sustainability, defined as the property of biological systems to remain diverse and produce indefinitely, entails several components. Environmental sustainability in our case would mean the maintenance of important ecosystem functions, such as climate regulation or soil fertility, and the conservation of Western Siberia's unique biodiversity. Economical sustainability would be achieved if profitability in agriculture and other land uses was guaranteed on the long run. Social sustainability would be met if the living standard of the rural human population stayed stable or increased rather than deteriorated.

When Russian and German land-use researchers first met in 2009, they were quick in agreeing that there are major knowledge gaps. How has land use changed since the break-up of the Soviet Union in 1991, and how will it change in the future? What does this change mean for the Siberian ecosystems and biodiversity, for agricultural business and for the people of the region? Will local change contribute to global climate change? Researchers and students from two Russian and five German universities and a German remote-sensing enterprise teamed up to answer these questions.

As study region, the forest steppe in the south of Russia's Tyumen province was selected, a landscape characterized by a mosaic of birch forests, grassland and cropfields, and part of the massive Western Siberian grain belt.

Mosaic of grassland and forest is typical for the Western Siberian forest steppe. In rural areas, people still use the landscape in diverse ways, such as these villagers who harvest wild strawberries (Immo Kämpf).

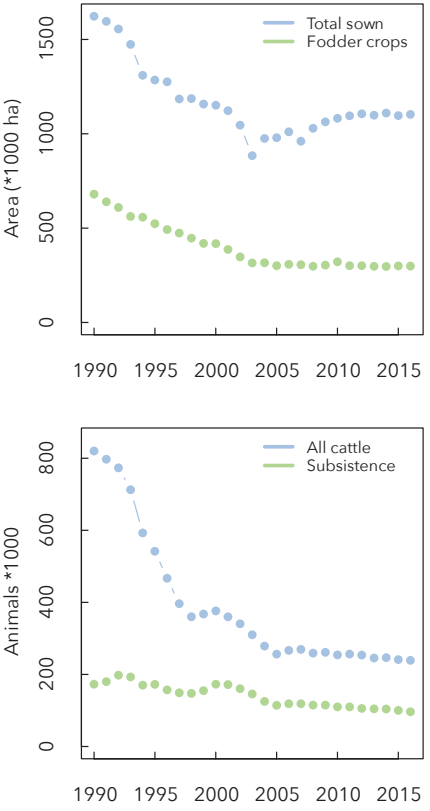
However, when the main research questions were answered, the project team did not rest. Hands-on work on the ground started, in order to develop farming techniques with local enterprises to make land use more sustainable. Politicians were approached with the agglomerated knowledge to influence far-reaching decisions. Different scenarios of potential future developments were set up and discussed widely with the public and decision makers.

The aim of this brochure is to introduce you to the research results, and to illustrate potential future pathways to more sustainable land use in Western Siberia.

THE CHANGING FORTUNES OF SIBERIAN AGRICULTURE

Agriculture has a long history in Tyumen province, despite the harsh climate with a short growing season. The fortunes of agricultural production in the Western Siberian grain belt were varied over the past decades: In Soviet times, state-run farms produced large quantities of grain and fodder, and the surplus was exported to many other parts of former Eastern Bloc. Millions of cattle and sheep were kept for meat and dairy production.

Political change in 1991, with the breakup of the Soviet Union into independent republics, resulted in disorder in economy and society. The Russian economy transitioned from a centrally planned to a market-oriented system. Farms were privatized and are no longer affected exclusively by Moscow's policies, but now also by global markets and demand[1]. When travelling the countryside of Tyumen province today, signs of change strike the eye: In many areas, derelict livestock stables are visible, each hosting hundreds of cows in Soviet times. Livestock breeding was hit hard by the collapse of the state farm system in the 1990s, and the number of cattle and sheep crashed in Tyumen province: Declines of up to 60% were recorded[2]: hundreds of thousands of animals.



Trends in the area sown for crops and livestock numbers in Tyumen province, for the period 1990 – 2015 (Tyumen Statistics Office 2016).

Following page: Abandoned cropfield, now used by the villagers as communal pasture (Immo Kämpf).

Soviet-time machinery is increasingly replaced with new tractors for the large Siberian fields (Insa Kühling).

Russia's livestock industry is only slowly recovering, and beef is still imported from Brazil and other countries despite the large land resources that could be used for grazing free-ranging herds. Similarly, many crop fields of the Soviet era are not in use anymore, especially those that are too unproductive under the new market conditions, or are situated in areas difficult to access with heavy tractors such as waterlogged depressions[3]. According to official land use statistics about 400 000 ha of crop fields were abandoned across the province after 1991[2, 3] – a huge land reserve.

However, during the last decade, agriculture in Tyumen province has gained momentum again[2]: Crop production concentrates now in the highest-yielding areas, Soviet-period machinery is gradually replaced with the latest brands allowing to farm much more efficiently, and fertilizer application is also more intensive leading to higher output per hectare. Tendencies to recultivate abandoned cropland become obvious from the official government statistics. Livestock breeding has been modernized, with most cattle now kept in stables yearround and fed with grain and fodder crops produced on the fields.

CULTURAL LANDSCAPES AT A CROSSROADS

It is not only the large-scale, industrial farming enterprises that satisfy local food demand. The rural communities in Tyumen province grow more potatoes in their village backyards than all big agricultural enterprises together[2]. Half of the livestock is owned by the villagers, who keep cattle and sheep for meat and dairy products[2]. Subsistence agriculture still plays an important role in the agricultural economy in Russia.

The forest steppe, this mosaic of small birch groves, wetlands and fields, has been shaped by man for thousands of years. And it still is: The cattle of the villages are grazed on communal pastures, shepherded in a

Every evening, the cattle is herded back to the village stables by a shepherd on horseback (Immo Kämpf).

Surplus milk is collected in the villages (Immo Kämpf).

A remote village in the autumnal forest steppe – how long will it still exist (Johannes Kamp)?

rotational community system or by professional 'cowboys'. The long and cold Siberian winter demands that all animals are kept in stables between October and March, fed mostly with hay. While some hay is bought from the big agricultural enterprises (that produce commercially), many families still cut their own winter storage on small meadows in the forest steppe[4]. Firewood comes from the birch forests, and berries are collected in large quantities to be sold on the local markets, contributing to the income of the rural population. However, the future for the picturesque wooden village houses and their inhabitants is uncertain. Just as in many other parts of the world, the call of the comfortable city life does not go unheard. Many of the villages have lost inhabitants and some are now completely abandoned. It is now so costly to support the remaining infrastructure in remote villages that with continuing outmigration, some will not persist. This will in turn lead to a decline in small-scale, low-input agriculture: pastures and hay meadows will either overgrow with shrub and slowly turn in forest, or will be claimed for more intensive agriculture, by big enterprises[5].

CLIMATE AND LAND-USE CHANGE: CLOSELY CONNECTED

The global climate is changing fast. Temperatures increase, precipitation patterns change, 'extreme' weather events, such as droughts and storms, become more frequent. Siberia, with its blistering cold temperatures in winter, and blazing hot summers has been identified as a global hotspot of climate change. And indeed, changes are already felt.

Talking to people on the streets of Tyumen City, situated in the hemi-boreal climate zone, many suggest that there is now less snow in winter. Summers became seemingly cooler and rainier than in earlier times. In contrast, villagers and farmers across the southern part of Tyumen province complain about dry years and resulting lower crop yields. Systematic research[6], based on the climate data collected at a large number of weather stations across Western Siberia for a period of 30 years, confirmed these impressions. A prediction of climate trends into the future suggests that the growing season will increase north of Tyumen, while agriculture will become riskier in the forest steppe as it gets drier. This will have implications for human wellbeing, infrastructure and land use. There is already significant financial loss among farmers in our study region: between 2008 and

2012, droughts resulted in yields sometimes 80 % below expectation, and in 2008, one big producer lost grain worth more than a million dollars. On the other hand, extremely cold and wet summers in recent years made the crops grow very slowly, and much grain was not ripe before the first snow and could thus not be harvested in time[7].

Climate change is closely connected with changes in land use. The greenhouse gas emissions heating up the atmosphere are not only caused by burning fossil fuels in industry and transport: Where natural vegetation is converted into cropland, carbon is released as CO_2 into the atmosphere. We could show that converting currently unused grassland into new cereal fields would clearly lead to more CO_2 being blown into the atmosphere: Ploughing turns greenhouse gas 'sinks' into sources[8]. We know now, how much we would lose: stores of up to 15 tons of pure carbon have built up per each hectare abandoned farmland across Tyumen province, which would largely be released after recultivation[9].

With the consolidation and recent growth in the agricultural sector in Tyumen province, a future expansion of cropland into currently unused areas seems likely. Farmers might exploit abandoned fields, but also convert new areas of natural vegetation in the north of the region that might become suitable for farming due to the longer growing season. This would result in emissions and depleted carbons stocks. A vicious feedback cycle – agricultural expansion due to climate change could lead to more climate change.

Future changes in climate will also affect water availability for agriculture: water will be scarce in drier summers and soils dry out, increased winter precipitation might lead to more streamflow in the Siberian rivers and tributaries[10]. As 90 % of the water runs off just after snowmelt[11], this will probably lead to more and longer inundation of the Siberian lowlands. Farmers rely on access to their field in this period – this will become increasingly difficult when soils remain waterlogged until May.

Mighty black layers rich in carbon characterize the Siberian Black Soils (Tim Wertebach).

A project member at an installation to measure greenhouse gas fluxes (Insa Kühling).

Following page: The water retreats from the inundated floodplain of the Tura river and reveals productive hay meadows (Steffen Kämpfer).

BIODIVERSITY: ANIMALS AND PLANTS RESPOND TO CHANGE

Western Siberia is a biodiversity hotspot: A large number of plants and animal species occurs together, as the temperate forests of Europe, the southern Russian Taiga and the dry Central Asian steppes meet in a transition ecozone, the forest steppe. Richness and abundance could be preserved until recently as pressure from land use was relatively low. Pastures and hay meadows are not worked very intensively. No fertilizer is applied, and there is only one cut late in the year. Livestock densities decline as one moves away from the villages. This creates a variety of grasslands with different vegetation characteristics.

The land-use changes that were triggered by the break-up of the Soviet Union had strong, but varying impacts on species communities. After the abandonment of cropland, wild nature recovered: through a return of the native vegetation, many former wheat fields now resemble the original meadow-steppe swards[12]. Similar patterns were observed in butterfly, grasshopper and bird populations[13] – abandoned cropland was quickly colonized even by species that have become rare or are declining elsewhere. Responses to a cessation of grassland management, such as grazing and haymaking, were mixed: Butterflies and grasshopper communities are similarly species-rich and abundant in pristine and abandoned

A Silver-washed Fritillary on a Turk's cap lily (Sarah Weking).

grassland[13, 14], but might gradually disappear as biomass accumulates, and swards get denser and cooler. Most birds were losers in this game: Especially rare and threatened meadow birds, such as Black-tailed Godwit and Redshank prefer a short-grazed lawn full of dung piles that attract many insects (a rich food resource) to a tall and dense meadow, with no view of approaching foxes and other predators.

SASCHA research also revealed that it is not the large, contiguous fields managed by large agricultural enterprises that host a high number and variety of species, but the grasslands intermingled with birch woods[4]. These mosaic landscapes are mostly managed by villagers for subsistence agriculture – producing most of the food you need on your own land. More abandonment and habitat loss is likely if the trend of rural outmigration continues, with negative consequences for the unique grassland biodiversity of the region.

However, the future is not all bleak for biodiversity: A warming climate opens up new niches for a number of animals, and some are able to significantly extend their ranges: Even during the relative short project period of five years, we were able to document a movement to the north in several insect species[15]. Such 'range shifts' will become more frequent with ongoing global warming.

A mosaic of small hay meadows and birch forests supports especially many plant and animal species (Wanja Mathar).

TESTING SOLUTIONS TO CHALLENGES IN LAND MANAGEMENT

The changes that took place after the fall of the Soviet Union entail both challenges and opportunities. Certainly, the collapse of the state farming system had negative consequences for employment in rural areas, and the economical sustainability of food production. However, as discussed earlier, the widespread abandonment of cropland had overwhelmingly positive effects on biodiversity and the restoration of degraded ecosystems. Similarly, the transition of cropland into grasslands was positive for the climate, as large amounts of carbon (that would heat up the atmosphere when released again) were fixed. Positive effects on water quality and quantity in the landscape were also observed.[11]

Acknowledging the local realities and employment needs, as well as a globally increasing demand for food, strategies avoiding new cropland reclamation were therefore desperately needed. Furthermore, it turned out that recultivation was not an option in many areas – too low were the expected yields that working the land would have been profitable under market conditions, and without the massive subsidies of the Soviet era[2].

After prospecting a larger number of farms in Tyumen oblast, the SASCHA agronomists soon realized there was room to increase the efficiency of crop production. Could an increase in yields on existing cropland perhaps offset the production losses caused earlier by land abandonment? How could such yield increases be achieved, without the typical harmful consequences of this process known as intensification? We tested solutions to this challenge, namely a farming technique known as 'no-till', being part of the 'conservation agriculture' magic box. Conservation agriculture generally means to achieve sustainable and profitable agriculture using three principles, minimal soil disturbance, permanent soil cover and crop rotations. No-till techniques avoid deep ploughing of soils prior to sowing, but rather sow the seeds directly into the stubble of the previous year.

But how would we know that no-till brought really higher yields than conventional techniques? In cooperation with a large local agricultural enterprise and a German manufacturer of agricultural machinery, a scientific field trial was set up. Two seeding parameters were varied, namely seeding depth and seeding rate (number of wheat seeds/ha). Both options were tested under conventional tillage, and no-till seeding, over three seasons. The results were unexpectedly clear: Grain yields were more than 10 % higher on no-till plots compared to conventionally worked plots. Furthermore, the measured soil moisture was on average 42 % higher on no-till plots compared to conventional-till plots, and fuel and labour costs were 73 % less[16].

Clearly, the technique has potential to increase yields, while saving farmers a lot of money. Increased soil moisture would mean positive news for the adaptation of agriculture to climate change, given that future temperature increases and higher frequency of summer droughts are expected. The word was spreading fast among farmers, and an expansion of the area under no-till is expected in our study region – just as in neighbouring Kazakhstan, where no-till wheat cultivation has quickly been established recently.

Wheat is sown directly into the stubble of the previous year ('no-till'-farming, above), and conventional tillage on the SASCHA experimental plots (below) (Insa Kühling).

WHERE THERE IS MUCK THERE IS BRASS: IMPROVING MANURE MANAGEMENT

The SASCHA agronomists had calculated that, despite the strong decline in animal numbers after 1991, manure produced in livestock systems was still an important source of greenhouse gas emissions, namely methane and nitrous oxides. The industrial farms, with huge numbers of pigs, cattle and chicken in stables, contributed 80 % of these emissions[17] – much less came from smallholder farmers and subsistence livestock owners. A reason for high emissions was that the manure produced was hardly distributed as fertilizer on arable fields, but simply dumped on fields close to the farms. This led to local contamination of water and soil. An economic assessment revealed that using manure on cropfields could substitute significant amounts of mineral fertilizer, thereby saving the farmers' money, and transferring nutrients back to the soil[18]. It would also be a measure to increase yields on existing cropland, thereby reducing the need for expansion. However, it seems important how this organic fertilizer is applied – far less environmental problems are caused if it is distributed in solid rather than liquid form (as practiced by most households that own cattle, to fertilize their potato plot). Another option would be to bring more livestock back to the large areas of pastures that currently lie unused – with positive consequences for biodiversity, as SASCHA research showed[4].

Free-ranging cattle are much more 'climate-friendly' (and probably happier) than those kept in stables year-round (Andreas Völker).

Depending on the economic development, the arduous work of manual hay cutting and stacking might either disappear or persist in the future (Insa Kühling).

ALTERNATIVE FUTURES: SCENARIO PLANNING FOR SUSTAINABILITY

After five years of interdisciplinary research, we have a good understanding of past change – but what will the future bring? Can we use our knowledge to make future land use more sustainable? What policies and institutions are needed to make the best out of future land use developments?

We realized that in a centrally planned country, where many decisions are made on provincial or even federal level, decisions of policy makers will have a tremendous impact on future land-use options. We also learnt that many current policies are not ideal to adapt agriculture to a changing climate[7], and to trigger developments from which the environment and people alike would benefit. Of similar importance is of course the profitability of land use – where measures to improve living standards or environmental conditions hamper growth and profits they are unlikely to be implemented. Keeping these two driving forces – political governance and profitability – in mind, we tried to assess potential future development in land management.

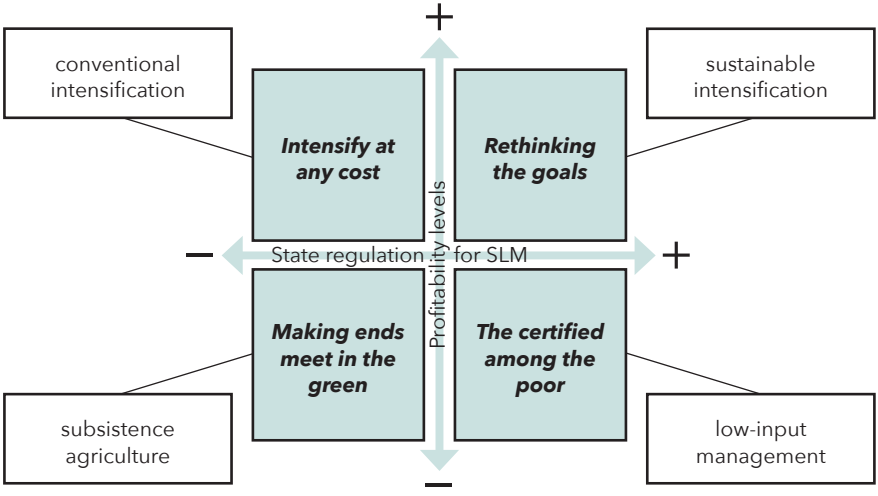
The only thing that seemed to be certain was uncertainty – we did simply not know what the future would bring. We therefore used a process called 'scenario planning' to compare potential future developments in a systematic framework. We interviewed countless farmers and politicians, and conducted role plays with university students and employees of the local administration. Using all the information gathered and opinions heard, we developed four 'scenarios' – short stories of potential future processes and actions that would cause various changes in the land use system. We did not aim at exact predictions of what the future will be, but rather illustrate the possible extremes of development and their implications, for a period starting now and ending around the year 2050. Which elements of the scenarios will become reality depends on international and national policies, but also on the way local people participate in shaping their environment.

SCENARIO 1: INTENSIFY AT ANY COST

Economic growth and flourishing exports of gas and oil allow for high agricultural subsidies. An increase in agricultural production is a chief goal of agricultural policy, regardless of the social and environmental costs. Cropland expands, but the region also suffers from low yields due to droughts and missing adaptation to climate change. Large, strongly mechanized agricultural enterprises offer only a limited number of jobs, and rural out-migration continues. Environmental-friendly production methods receive little attention. Agricultural intensification and cropland expansion cause losses of biodiversity and soil organic carbon stocks.

SCENARIO 2: MAKING ENDS MEET IN THE GREEN

National and global policies results in a long economic recession lasting until 2050. As the state curbs agricultural subsidies, many farms go bankrupt. Big agricultural enterprises redirect investments to the oil and gas industry. The region faces massive rural depopulation. The remaining small farms organize into marketing cooperatives to survive. Livestock numbers and the small-scale household plots increase as most village families produce foods for subsistence. A lot of farmland is abandoned. The state withdraws from regulating agriculture, environmental requirements to agriculture stay low. Biodiversity recovers on former arable land, but many species of the cultural landscape are lost. With strong vegetation succession on abandoned land, carbon stocks build up on a large scale, and water quality increases.



A graphic representation of the main drivers (profitability and state regulation in agriculture) of agricultural development and resulting alternative future scenarios (Yuliana Griewald).

SCENARIO 3: THE CERTIFIED AMONG THE POOR

Until 2040 Russia sees a stable economic growth. The environmental awareness of the population increases. The potential of the region for free-ranging livestock systems is realized, and livestock numbers recover. Certification schemes for low-input livestock management and organic farming are developed and organic meat is exported on a large scale. Around 2040, a sudden economic crisis breaks out and transitions into a long-term recession. As subsidies are cut, many farms collapse. After an initial stabilization, the rural population starts leaving the countryside. Only those producers remain afloat who are already part of certification schemes for low-input management and have well-established contacts abroad. Biodiversity thrives in the first phase, as low-input livestock management creates a lot of habitat.

SCENARIO 4: RETHINKING THE GOALS

Economic growth and thriving international cooperation lead to the inclusion of environmental issues in agricultural policy. Agricultural subsidies are in place, and farms' environmental performance becomes one of the subsidy criteria. Improvements of rural infrastructure and job opportunities slow down rural out-migration. State-organized competitions such as 'Best Biodiversity Saver' and 'Climate's Best Friend' replace the 'Fastest Harvester' competitions. Policy acknowledges the mosaic of arable land, grassland, and forests as an indispensable component of the traditional Western Siberian landscape. Conservation agriculture measures such as no-till farming and prudent manure management become established on a broad scale. The Tyumen region annually achieves climate and biodiversity goals and becomes a role model among crop-producing Russian regions.

Following page: Black cows or shiny churches? Contrast between rural and urban life illustrated in Tobolsk city (Johannes Kamp).

WHAT WILL LAST?

After five years of joint fieldwork, countless workshops and student trainings both in Russia and Germany, virtually all researchers and students involved would agree that working in Russian-German teams was a rewarding experience. The German researchers were given the unique opportunity to broaden their horizon in the untouched wilderness and intact cultural landscapes of Siberia – landscapes that had been lost over large parts of Europe centuries ago. Researchers of both countries profited from new viewpoints and updates on the latest research methodologies, scientific literature and standards in the Russian and Western systems. Equally (or perhaps even more) important that the scientific achievements seems the mutual cultural understanding that resulted from the SASCHA project – an acquaintance of new language skills, both literally and in the cultural sense. This has formed a basis for future stable collaboration and new bilateral projects are already developed.

Russian and German students attending a joint field course organized by the SASCHA project (Johannes Kamp).

FURTHER READING: SCIENTIFIC ARTICLES ON SASCHA PROJECT RESULTS

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This booklet presents the findings from an interdisciplinary research project that involved Russian and German partners from academia, policy-making and agriculture. How can we meet the challenges of global food production for Siberia's agriculture in a changing climate? How can we maintain the wildlife and important ecosystems of Siberia's forest steppe under rapidly changing socio-economic conditions? A group of more than 30 researchers and students from both countries addressed these questions between 2011 and 2016. Ecologists, climatologists and agricultural scientists teamed up to test solutions for more sustainable agriculture in the forest steppe. A scenario planning exercise builds on the research results and illustrates alternative future development. The results are encouraging: environmental sustainability can go hand in hand with high levels of profitability and rural development in Siberia, when all local actors pull together.

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SUSTAINABLE LAND MANAGEMENT

SASCHA