WORLD COFFEE RESEARCH™

ANNUAL REPORT
2015

WCR is helping producers in Guatemala replant their farms with rust-resistant varieties.

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EXECUTIVE SUMMARY

In 2015, World Coffee Research completed major projects with results that will be transformative in ensuring the future of coffee.

We completed a milestone in advancing the science of coffee flavor with the launch of the World Coffee Research Sensory Lexicon, a rigorous new tool to evaluate coffee's sensory qualities. It was published in January 2016 and has already been adopted as the basis for an inconic redesign of the Coffee Taster's Flavor Wheel. See p. 13.

The WCR coffee breeding program took a major step toward the development of new, high yielding, high quality, and climate-resilient coffees for Central America. In 2015, our breeders created 50 new experimental F1 hybrids that will be evaluated for disease resistance, cup quality and productivity at three locations in Central America. See p. 31.

We created the F1 hybrids using a powerful new tool established in 2015: The WCR Core Collection, a group of 100 of the most genetically diverse Coffea arabica coffees from the CATIE germplasm collection, one of the most important sources of coffee genetic diversity outside of Ethiopia. It will form an essential new reservoir of genetic diversity for coffee breeders for decades to come. See p. 30.

We brought the International Multilocation Variety Trial to the Democratic Republic of Congo and Indonesia, raising the number of participating countries to 19. See p. 22.

We published a major study that describes the main climates that support coffee cultivation and pinpoints which of these zones is most vulnerable to climate change. See p. 16.

We launched a network of on-farm demonstration trials in Africa and Central America through workshops with public and private partners. The goal of the network is to get high-performing varieties into farmer fields and show with hard data how they can improve farmer profitability. See p. 18.

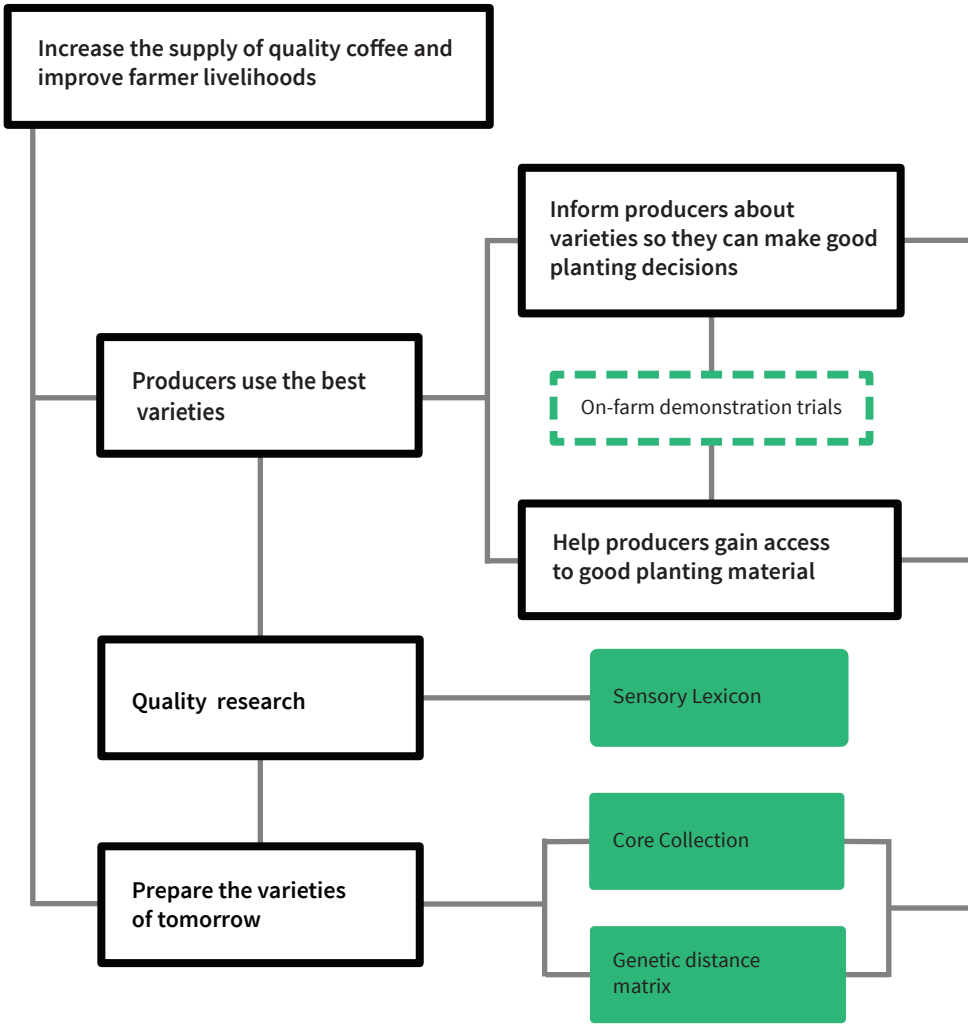
We established a brand-new WCR research farm in El Salvador, which will become our headquarters in Central America. The research farm is testing rust-resistant varieties, working on cup quality enhancements, and testing new products to control coffee leaf rust. See p. 20.

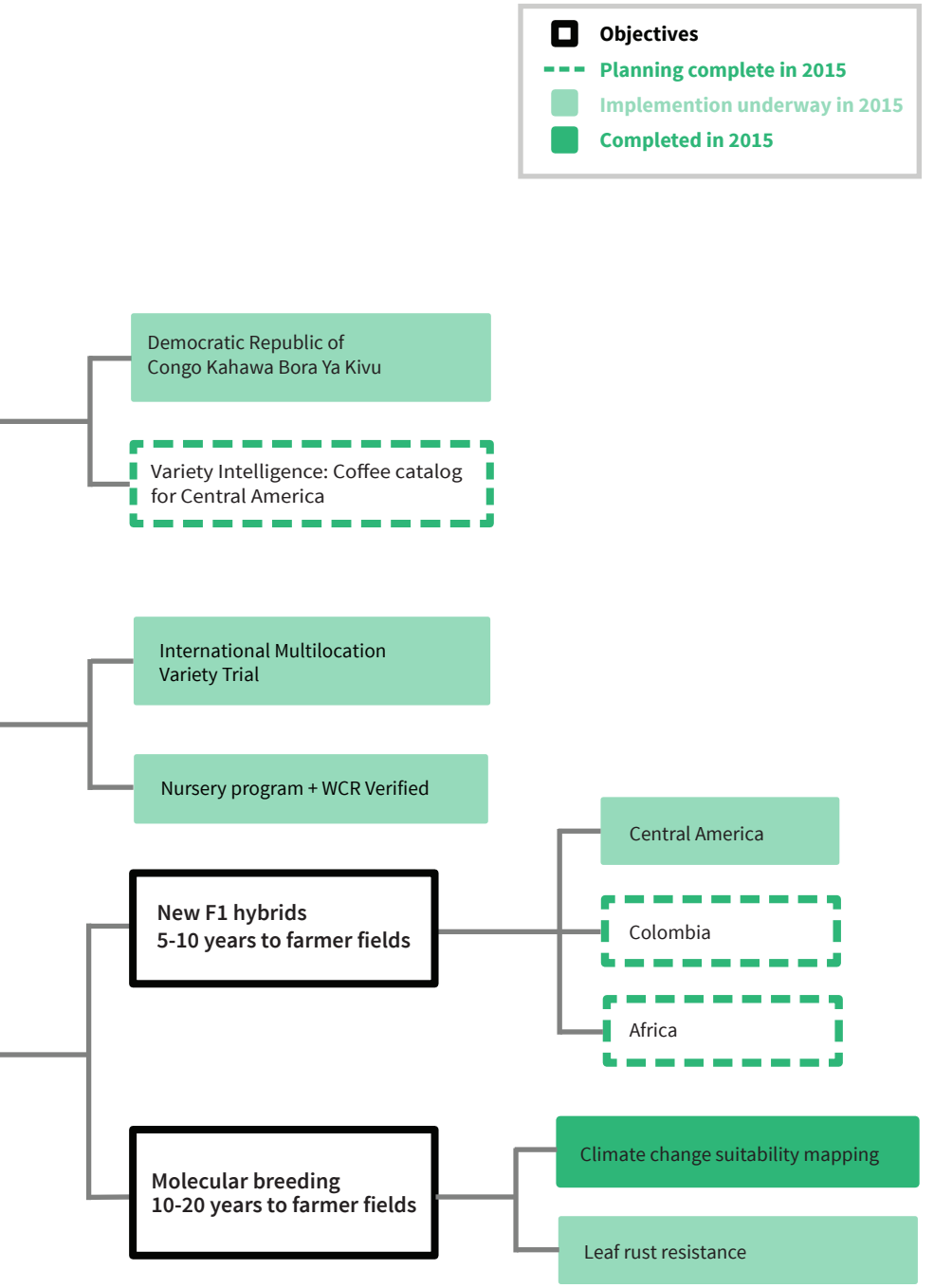
About This Report

This report covers World Coffee Research activities, highlights and results for the period from January 1, 2015 to December 31, 2015.

OUR WORK IN 2015

Focusing on improving coffee plants is the most efficient and economical way to increase productivity and quality.




Objectives
Planning complete in 2015
Implemention underway in 2015
Completed in 2015
Democratic Republic of Congo Kahawa Bora Ya Kivu
Variety Intelligence: Coffee catalog for Central America
International Multilocation Variety Trial
Nursery program + WCR Verified
New F1 hybrids 5-10 years to farmer fields
Central America
Colombia
Africa
Molecular breeding 10-20 years to farmer fields
Climate change suitability mapping
Leaf rust resistance

WHO WE ARE

We are the coffee industry's global research team. A collaborative, not-for-profit 501(c)5 research organization, we were formed in 2012 to ensure the future of coffee in the face of threats like climate change.

Mission. *To grow, protect, and enhance supplies of quality coffee while improving the livelihoods of the families who produce it.*

Vision. *To create a toolbox of coffee varieties, genetic resources and accompanying technologies and to disseminate them strategically and collaboratively in producing countries to alleviate constraints to the supply chain of high quality coffee.*

IMPACT

Coffee producers are the stewards of both quality and productivity. To enhance their livelihoods and ensure coffee's future, we must provide farmers and industry with better tools: Better data about what works and what doesn't, better coffee plants, better solutions for diseases and pests, and better approaches for climate change adaptation.

The fastest, most sustainable way to achieve this is through collaborative research. World Coffee Research brings together scientists from around the world to create new knowledge about the constraints on quality and productivity, identify the "best bang for the buck" solutions, and ensure that results get to farmers.

Our globe-spanning trials and projects in 22 countries are all designed to deliver:

- Higher quality coffee.
- More productive coffee farms.
- More sustainable and dignified livelihoods for coffee farmers.

Our Research Along The Supply Chain

The Coffee Plant + Agriculture

Coffee genetics and breeding
Sustainably, efficiently improve coffee productivity and quality

Coffee varieties
Expand knowledge of and access to best varieties

Climate change
Help farmers adapt to rising temperatures

Coffee diseases and pests
Address + monitor the most immediate threat to coffee producers

Processing

Fermentation
Understand the impact of fermentation on coffee flavor

Export and Supplies

Supporting farmer profitability
Help farmers imporve their livelihoods

Roasting

Understand how roasting affects flavor

Marketing

Corporate social responsibility

Consumption

Coffee quality
Understand the basis for quality and create tools to improve it

HOW WE WORK

Collaboratively

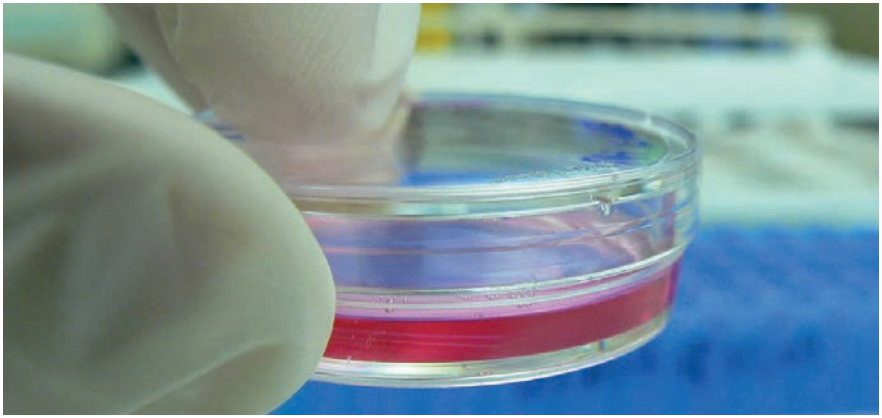
We don't do this work alone. We collaborate with the best minds in coffee science, wherever they are. See a full list of our partners on p. 47.

Globally

Most of our research is done in the places where coffee is grown. We partner with local research institutions, coffee organizations, governments, and NGOs that can ensure maximum impact.

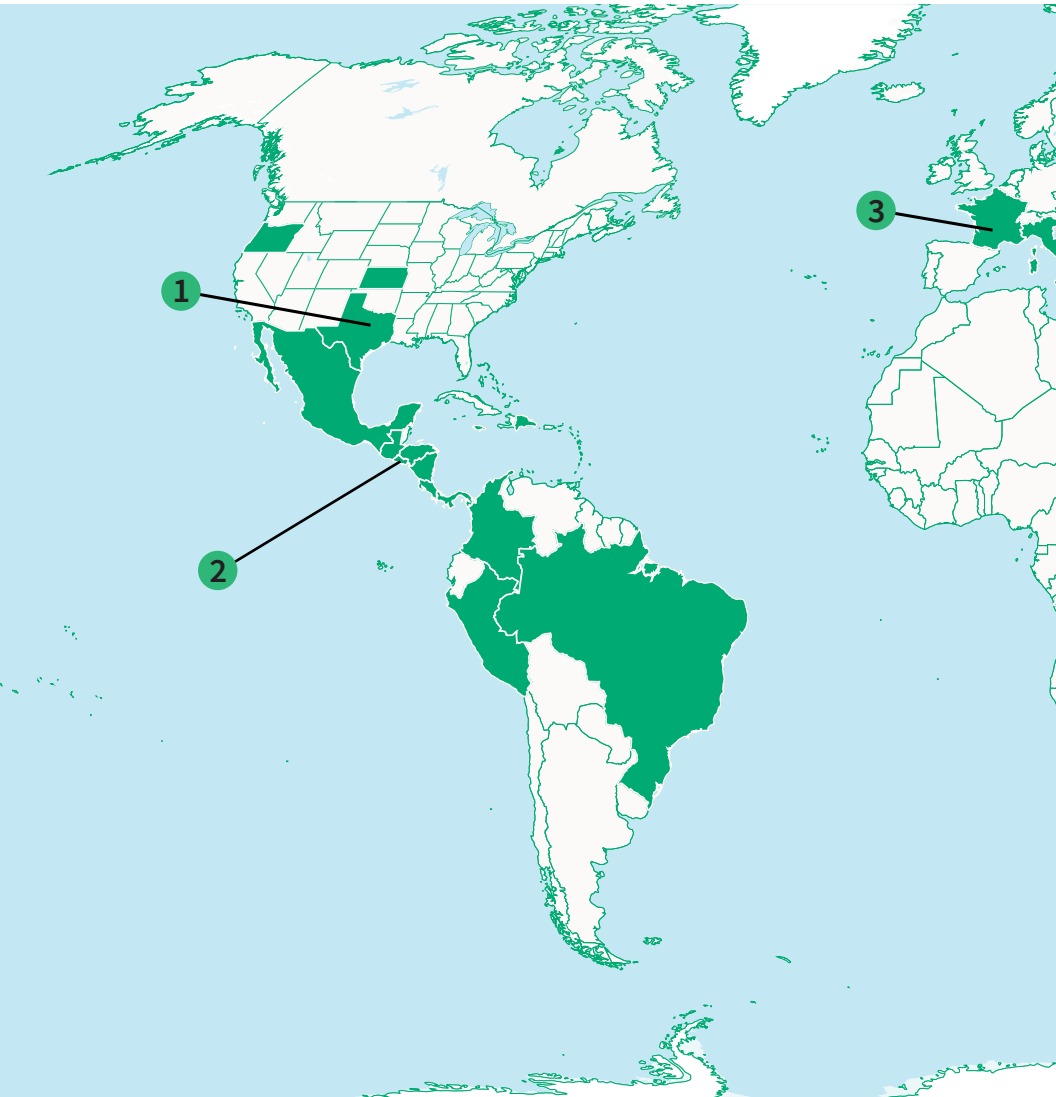
Openly

No one company or country benefits from our work—it is done for the benefit of the entire coffee industry, and especially for the benefit of coffee producers who are the stewards of coffee quality and productivity.

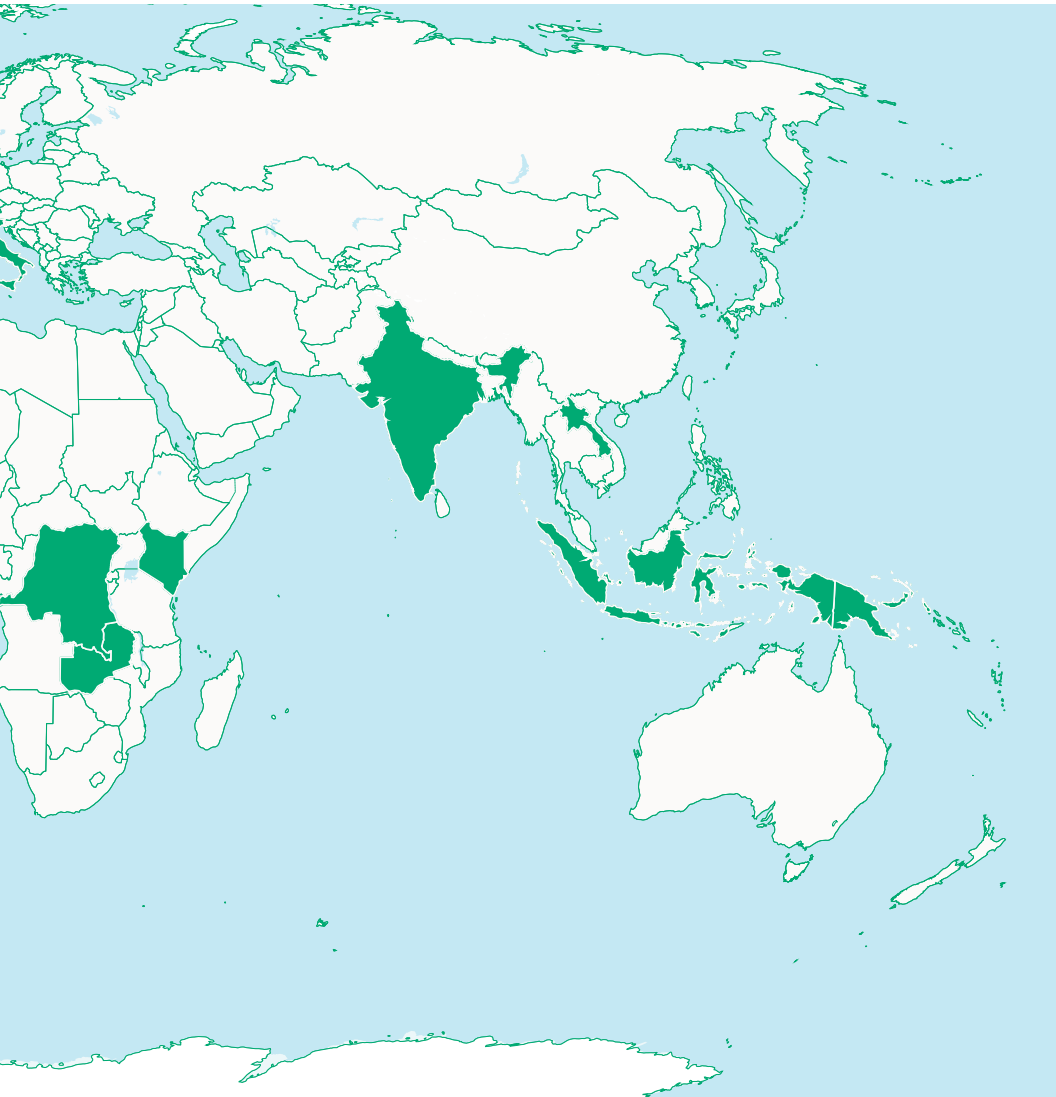


WHERE WE WORKED IN 2015

Brazil
Colombia
Costa Rica
Democratic Republic of Congo
Dominican Republic
El Salvador
France
Guatemala
Honduras
India
Indonesia
Italy
Jamaica
Kenya
Laos
Mexico
Nicaragua
Panama
Papua New Guinea
Peru
United States
Zambia



1. WCR Headquarters (College Station, Texas)
2. WCR Research Farm (Santa Ana, El Salvador)
3. WCR Executive and Scientific Direction (France)



DELIVERED IN 2015

The World Coffee Research Sensory Lexicon

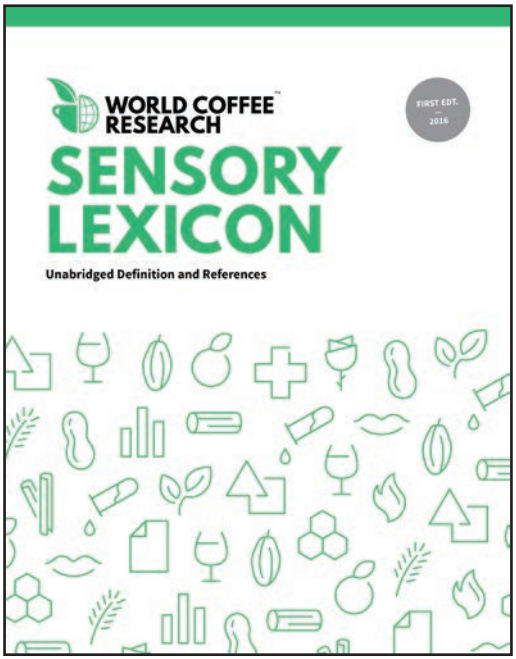
Understanding the Impact of Climate Change

African Coffee Renaissance Initiative

The World Coffee Research Sensory Lexicon

A new tool for measuring coffee quality

Published January 19, 2016



In order to understand the origins of coffee's sensory qualities—the complex interaction between chemistry and our senses that determines what we experience—we must first have a tool that lets us measure them. The World Coffee Research Sensory Lexicon uses a sensory science approach to identify coffee's primary sensory qualities, and to create a replicable way of measuring them. Sensory scientists at Kansas State University who developed the lexicon identified 110 flavor, aroma, and texture attributes based on an analysis of 105 coffee samples from 13 countries. The lexicon defines these attributes and provides references for measuring their intensity in coffee samples.

The lexicon will allow coffee researchers and breeders to locate specific sensory qualities of different coffees and begin to identify correlations between them and the presence of volatile compounds, physical aspects of beans, and gene expression to ensure these factors are taken into account in future breeding efforts to create the highest possible quality. By giving researchers and the coffee industry

a unified language of flavor for coffee, more targeted advances in beverage quality can be made. The lexicon is a living document and will grow over time.

"The idea that there is now an organization leading the way with a specific tool that can be used to look for characteristics in developing coffee varieties more thoughtfully and purposefully is simply beautiful."
—Timothy Hill, coffee buyer and quality manager, Counter Culture Coffee

The basis for a new flavor wheel

Perhaps the most important and far-reaching application of the lexicon so far is the release of a new Coffee Taster's Flavor Wheel based on the lexicon, a collaboration between World Coffee Research and the Specialty Coffee Association of America. It is the first time in 20 years the wheel has been redesigned and is the first time the industry-standard wheel has been based on rigorous research. Funds from the sale of posters bearing the iconic wheel images will support future sensory research.

The Colombia Sensory Trial: The lexicon in action

The Colombia Sensory Trial was the first rigorous field study to apply the lexicon and prove its value. The goal was to understand the impact of coffee genetics (i.e., cultivar) on coffee quality.

Researchers from Kansas State University conducted a sensory analysis comparing Castillo and Caturra cultivars grown under similar agroecological conditions on 22 farms in Nariño, Colombia. Coffee cherries of each type were harvested and processed identically and strictly separated throughout the harvest and post-harvest processes. Samples were evaluated by both expert coffee cuppers and by trained sensory scientists using the World Coffee Research Sensory Lexicon.

Cuppers using formal cupping evaluation failed to find differences between the scores of Castillo and Caturra (both averaged 86 points). But using the lexicon, sensory scientists were able to isolate statistically significant differences in the flavors of Castillo and Caturra. Castillo tasted fruity but not citrusy, with notes of dark chocolate and roasted nuts. Caturra tasted floral with notes of cocoa and caramel. The ability to quantify sensory differences between coffees is an incredible breakthrough in analysis of coffee.

The new SCAA/WCR Coffee Taster's Flavor Wheel is based on the World Coffee Research Sensory Lexicon. It is the first time the wheel has been updated in over 20 years.

Understanding the Impact of Climate Change

Preparing for the future

Published October 27, 2015

New research on coffee and climate change conducted by World Coffee Research and the International Center for Tropical Agriculture (CIAT) will allow dramatic improvements in climate adaptation efforts for arabica coffee growers and industry. It was published in the open-access journal PLOS ONE.

Previous studies of coffee and climate change distinguished only between areas that are or will be "suitable" or "unsuitable" for coffee growing. This limited their practical usefulness for adapting coffee to climate change. This study unlocks the "black box" of suitability and shows how the different climate zones are expected to fare over the next 35 years. This is the first time researchers have predicted coffee's current and future climate zones globally.

Key findings

- The study describes five different agroecological zones in which coffee is able to grow today: hot-wet, hot-dry, cold, cold-dry and constant.

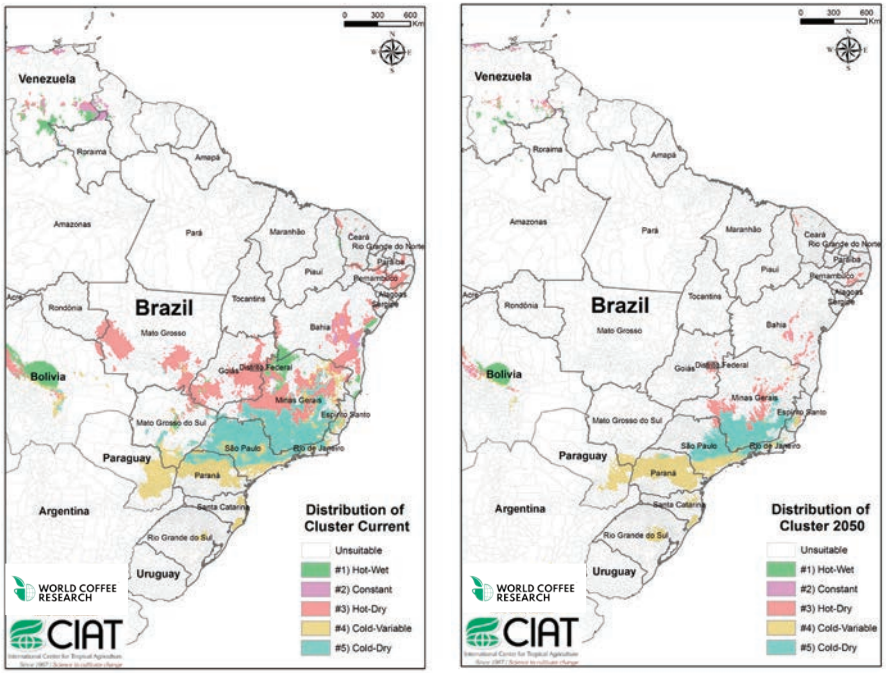
- It reinforces predictions of dramatic reduction in land area suitable for arabica coffee production by 2050.

- It gives a detailed picture of which coffee climate zones will be most affected by 2050.

- The highest losses will be in hot, dry regions such as northern Minas Gerais state in Brazil, parts of India, and Nicaragua—areas that currently give some of the highest yields of arabica coffee. Nearly 80% of the land in this climate zone will become unsuitable for coffee by 2050.

- Areas around the equator with seasonally constant temperatures, including many parts of Colombia, Ethiopia, Kenya and Indonesia, will be least affected by climate change. Approximately 60% of areas with this climate will be unchanged in 2050—good news for the specialty coffee industry, which relies on these regions for its highest quality coffees.

"Overall, the arabica market is extremely threatened. There is rising demand. In the future, we'd need more area to grow coffee on, but we're going to have less." —Christian Bunn, lead author, CIAT



The study predicts that nearly all of the coffee area in Brazil's hot-dry areas (shown in pink) will become unsuitable for coffee production by 2050.

Full Article: Bunn C, Läderach P, Pérez Jimenez JG, Montagnon C, Schilling T. 2015. Multiclass classification of agro-ecological zones for arabica coffee: an improved understanding of the impacts of climate change. PLOS ONE 10(10): e0140490. doi: 10.1371/journal.pone.0140490

African Coffee Renaissance Initiative

Improving the profitability of farming in Africa

Launched October 2015

WCR researcher Christophe Montagnon visits coffee producers in Muranga County, Kenya.

Africa's coffee production has declined precipitously in the last four decades to only 13% in 2012-2013. Coffee producutivity in Africa is the lowest on the planet and coffee farm profitability has declined to the point that farmers are abandoning coffee in favor of other crops.

With the right strategies, coffee farming can be profitable in Africa. In 2015, WCR and the Africa Fine Coffees Association launched a joint initiative to get existing, high-performing cultivars into the hands of African coffee producers, along with appropriate soil treatments.

At a summit held in Nairobi, Kenya, in October 2015, WCR proposed the establishment of a network of on-farm demonstration trials (50 sites in 9 countries for 2016). Coffee roasters, exporters, and cooperatives will support the cost of plantlets and soil treatments, which means farmers will assume less risk, while the

benefits resulting from higher yields and quality will be shared by coffee farmers and coffee buyers alike. WCR-trained specialists will train participating farmers in best agronomic practices for the selected coffees and in financial tools to track the impact on farm profitability.

We estimate that within five years, the farmers who adopt renovation packages will double or triple profits on their demonstration plots and will seek more new seedlings and soil treatments to increase the renovation areas on their farms. Demand for the renovation package from neighboring farmers will also increase exponentially as package performance is verified, talked about, and transformed into hard cash. This is the kind of "marketing with hard data" that has historically been missing from extension and technology transfer programs.

The program will support the emergence of an African coffee seed sector to bolster demand for new varieties. As the project grows, it will significantly increase production and profitability for farmers across the continent.

Because the plots will also have a common design, data collected throughout the network will be comparable across time and space, allowing WCR and others to aggregate results and recommend the best varieties and soil treatments for extension and to inform future research.

WCR hosted a coffee breeding and genetics workshop took place at Coffee Research Institute Kenya in October 2015 with researchers from across Africa.

SHARING OUR WORK

WCR Research Farm

In 2015, a seven-hectare farm located in Santa Ana, El Salvador, was gifted to WCR by J. Hill & Company and members of the Aggie Association of El Salvador, Eduardo Palomo and Mario Mendoza, to further our research mission.

The farm received renovations in fall and winter 2015 to install a new perimeter fence, upgrade worker and guest facilities, and improve infrastructure. It has been selected as a central site for the WCR Core Collection, 100 genetically diverse arabicas that will be planted on the farm and used in breeding experiments (see p. 20). Future plans for the farm include rootstock evaluations, soil amendment validation, breeding, and disease-related experiments. In the coming years, the farm will become WCR's Central American headquarters for coffee research and a site for training and educational programs.

Operations funding has been provided by J. Hill and Mars Drinks.

Eduardo Palomo, Tim Schilling, and Mario Mendoza look over the WCR Research Farm.

ONGOING PROJECTS

International Multilocation Variety Trial

Variety Intelligence and WCR Verified Program

Coffee Leaf Rust in Central America

World Coffee Research Breeding Program

Climate Change Research

Sensory Research

Kahawara Bora Ya Kivu

International Multilocation Variety Trial

Understanding our best varieties

Preparing the IMLVT site at Thevada Estate in Laos.

35 varieties from around the world. 40+ test plots in 19 countries. 50,000 plantlets.

The International Multilocation Variety Trial is a first-of-its kind undertaking to facilitate the global exchange of the world's highest quality coffee varieties.

After two years of planning and negotiations, World Coffee Research has gathered 35 top-performing coffee varieties from 11 suppliers around the world. In 2015, we continued replicating them in sterile in-vitro cultures at the Agristarts phytosanitary lab in Florida and began sending them to participating countries. Each country will plant the coffees on test plots, where they can be monitored for performance under local conditions. The best-performing coffees can then be selected, multiplied, and distributed to producers to increase supplies of quality coffee for those countries.

Impact

Never before has a global variety exchange taken place on this scale in the coffee industry. Never before have most of these countries had in their possession so many different arabica coffees. This will result in widespread production and quality increases in as little as five years. In addition, the trial will serve as a platform to monitor disease movement and levels, climate trends, and the interaction between genetics, environmental factors, and quality.

Varieties were transplanted from the nursery to the field at the IMLVT site in El Salvador.

Milestones for 2015

- 12,000 plantlets (representing 28 of the 35 total varieties) were shipped in sterile containers to 14 of 19 participating coffee growing countries, where they were cared for in nurseries.

- In six countries seedlings were transferred from the nursery into experimental field plots. The remaining countries are expected to establish field plots in 2016.

- In 2016, we will take our first performance measurements, including plant vigor, coffee leaf rust susceptibility screening. As the plants mature, we will also evaluate bean characteristics and quality, drought tolerance, and susceptibility to other diseases.

- Two new countries joined the trial in 2015: Democratic Republic of Congo, through a partnership with the Institut National pour l'Etude et la Recherche Agronomiques (INERA), and Indonesia, through a partnership with the Indonesian Coffee and Cocoa Research Institute (ICCRI). We expect more countries to join the trial in 2016.

Variety Intelligence and WCR Verified Program

Information is power

The Variety Intelligence project brings urgently needed information to coffee farmers in Central American and the Caribbean to help them decide which coffee is best for their situation, and to ensure they have access to healthy, genetically pure plants.

There are four pillars:

1. A catalog of coffee varieties to enable farmers to make informed decisions
2. A manual of best standard nursery practices to ensure healthy plants
3. Genetic purity tests to ensure that farmers are getting what they paid for
4. A commitment to respecting plant breeders' rights

A core component of Variety Intelligence is the WCR Verified program, a platform for verifying the health and genetic purity of seed stocks available through nurseries. The program enables producers to be certain that their purchases are good ones, and builds trust between seed sellers and farmers. Nurseries who are verifying seed stocks through WCR will be required to make the coffee catalog available to farmers, to follow nursery best practices, and to submit stocks for genetic purity tests.

Impact

The coffee catalog will be distributed to tens of thousands of coffee farmers through national coffee institutions, exporters, cooperatives and nurseries that supply coffee plants and seeds. We expect that producers who use the catalog and plant Verified (healthy and genetically pure) planting material can expect to increase both the quality and volume of coffee by 10-15%. As significant numbers of farms are renovated in the coming five to ten years, the overall boost to productivity in the region could be significant and will enable the emergence of a professional seed sector for the coffee industry.

A workshop with nursery and plant experts was held in Guatemala in fall 2015.

Milestones for 2015

- We completed the report "Variety Intelligence for PROMECAFE Countries," a comprehensive overview of the varietal landscape in the region, based on interviews of 120 people from 70 private and public bodies involved in the national or regional coffee sector. The report will inform the creation of a coffee catalog of Central American varieties for farmers and nurseries in the region, to be published in 2016.

- We held a workshop with nursery experts to create a manual that outlines the best standard nursery practices to ensure plant health. The manual will be published in 2016.

- We identified three nurseries where the WCR Verified program will be piloted in 2016: J. Hill Coffee Producers in El Salvador, Pilones de Antigua in Guatemala, and ECOM Trading in Nicaragua.

Leaf rust in Central America

Fighting back against an epidemic

A leaf infected with coffee leaf rust. The spores of the fungus are spread by rain and wind.

World Coffee Research took quick action in 2013 to convene a rust summit in Central America focused on the coffee leaf rust epidemic that began in 2012. In 2014, WCR and USAID established a $5 million partnership to fund a program to monitor, control, and prevent rust in throughout Central America. The project, led by WCR and PROMECAFE with contributions from CATIE, CIRAD, and private industry, has made progress on multiple fronts.

Milestones for 2015

- In collaboration with CATIE, we are developing a farmer's manual that outlines best practices for managing coffee leaf rust.

- We initiated a three-year project to provide farmers badly affected by coffee leaf rust with rust-resistant coffee plant seedlings on three cooperatives in Guatemala. The farms will also be the site of a socioeconomic study exploring the impact of improved varieties on farm profitability. The project is funded by the Starbucks Foundation.

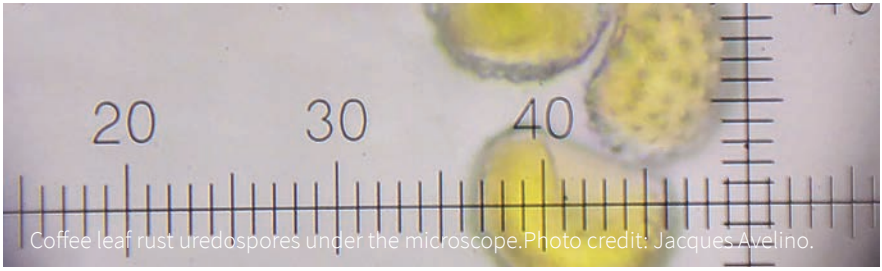
- We are conducting a study to identify biological organisms that may protect coffee from coffee leaf rust. In 2015, a scientific expedition to Kenya identified fungi that evolved alongside arabica coffee. The fungi are being studied for their ability to control coffee rust at the University of Viçosa in Brazil.

- In partnership with CIRAD and CATIE, we are conducting an experiment to understand the effect of shade type and agronomic management on rust incidence.

- In partnership with CATIE, we are fine-tuning methods to efficiently mass-produce coffee-leaf-rust-resistant coffee seedlings through the use of microcuttings. This will serve to lower the cost of next-generation F1 hybrids and allow smaller nurseries to propagate hybrids themselves.

- For more information on other projects connected to our work on coffee leaf rust, see p. 12, p. 24, and p. 30.

WCR scientists are collaborating with researchers from CATIE in Costa Rica on multiple projects relating to leaf rust.



Coffee leaf rust uredospores under the microscope.Photo credit: Jacques Avelino.

Project highlight: Yield, quality, and coffee leaf rust—untangling the relationships

Coffee plants are often described based on three key characteristics: cup quality, productivity, and disease resistance. Previous research has shown that cup quality may increase when plants produce less fruit. Others have shown that lower fruit production is correlated with an increased tolerance to coffee leaf rust. But high fruit production, resistance to coffee leaf rust, and high cup quality are *all* key to farmer profitability. Identifying the genetic mechanisms behind these effects will be essential for creating new varieties of coffee that are tolerant to coffee leaf rust and other stressors while maintaining high yields and having good quality—a major focus of efforts by WCR and others to support farmer profitability and reduce the incredible economic and social losses caused by coffee leaf rust.

To understand the interrelationship between these three key factors, PhD student Fabián Echeverría Beirute is comparing the performance of two varieties: Catuai (a common inbred variety), and H3 (a recently developed, clonally propagated F1 hybrid) at the Aquiares farm in Costa Rica. He is evaluating the effect of thinning fruit to 50% on cup quality and tolerance to coffee leaf rust.

Milestones for 2015

- Confirmed in trial setting that lower fruit load was correlated with reduced rust incidence and faster fruit maturation compared to the unthinned control.

- Processed bean samples from thinned and unthinned plants and readied them for chemical compound and beverage quality analysis using the new World Coffee Research Sensory Lexicon (analysis will be completed in 2016).

- Collected samples from experimental plants for RNA sequencing to search for the possible genes expressed and affected by the rust presence, yield level and variety.

Advisors to WCR's research program on coffee leaf rust met in Antigua, Guatemala in January 2015.

PhD student Fabián Echeverría Beirute holds samples of coffee prepared for his research into the effects of fruit load on quality and coffee leaf rust resistance.

World Coffee Research Breeding Program

Coffees for the future

WCR coffee breeder Benoit Bertrand examine seedlings from the Core Collection.

We already have significant evidence that commonly cultivated C. arabica coffees will not tolerate the environmental threats of the 21st century—changing weather patterns, increased temperatures, and new disease and insect prevalence. This creates a potentially disastrous decline in supply in the coming decades.

The coffee industry cannot single-handedly reverse climate change. Our best hope for sustaining the supply of high quality coffee in the 21st century is to focus on making the coffee plant more resilient. The creation of new, highly adaptable coffees, supported by a vibrant new seed sector, will result in major global productivity and quality gains in the next 10-20 years.

WCR Core Collection

Through an analysis of 847 arabica strains from the CATIE genebank, WCR located the 100 most genetically diverse individuals. These plants, which we call the WCR Core Collection, will be used by us and others to develop new hybrids that combine maximum genetic diversity with high performance. The collection has been grown into seedlings, which will be planted on three research farms in Central

America in 2016. It will form an essential new reservoir of genetic diversity for coffee breeders for decades to come.

Arabica genetic distance matrix

The data analysis used to create the Core Collection also allowed us to determine how genetically different the plants are from one another. This "genetic distance matrix" is an essential tool for creating more productive coffees. Generally in plant breeding, the greater the genetic distance between two parents of hybrid offspring, the more "vigorous" the offspring will be, a property known as heterosis. In coffee, heterosis frequently translates to productivity, uniformity, and better vegetative growth (prior work has shown productivity increases of 30-40%). Using the genetic distance matrix, WCR's breeders can take existing high-performing coffees known for desired traits like quality (e.g., Geisha) or disease resistance (e.g., Obata), and locate mates that are genetically distant to maximize heterosis in the offspring.

Improved coffee varieties like this F1 hybrid, called Centroamerica, have the potential to dramatically improve coffee yields while maintaining quality.

Regional, collaborative breeding programs around the world:

Central America

Both the Core Collection and the genetic distance matrix were put into use for the first time in 2015 to create the next generation of F1 hybrids for Central America. WCR's breeding team held a workshop in January 2015 with partners to determine what qualities are preferred for two new varieties—one compact, with high productivity (30-40% more than Caturra), resistance to coffee leaf rust, and high cup quality (as good as or better than Caturra), for elevations between 800 and

1200 meters; the other tall, with very high quality, productivity higher than Bourbon, and better tolerance of rust, for elevations above 1200 meters. In fall 2015, 50 crosses were made using established types including Geisha La Luisa, Obata, and Marsellesa. In 2016, the offspring will be germinated, transplanted, and observed for performance, including rust resistance and drought tolerance. Successful varieties may be released in as few as five years.

Colombia

In 2015, WCR and CENICAFE entered discussions about building a collaborative coffee-breeding program for the region. WCR and CENICAFE want to develop a common agenda to do the following:

- Sequence the genomes of part of CENICAFE's germplasm collection
- Evaluate the WCR Core Collection for coffee leaf rust resistance
- Develop new F1 hybrids well-adapted to Colombian growing conditions and highly resistant to coffee leaf rust and CBD
- Develop interspecific plants to be used in an international pre-breeding program
- Evaluate the quality of Geisha coffee in different Colombian locations

Africa

In October, WCR and the African Fine Coffees Association convened a meeting of coffee breeders and researchers from across the continent to jumpstart a collaborative coffee breeding program for the region. The researchers endorsed a plan to bring the WCR Core Collection to the Coffee Research Institute in Ruiru, Kenya, which volunteered to serve as a regional breeding hub. In 2016, WCR's coffee breeders will meet with breeders from participating African countries to create a list of ideal characteristics for new cultivars. Local breeders will work with WCR to use the Core Collection to create new crosses.

Molecular breeding

WCR is working to create a comprehensive database of genes and markers for important arabica coffee traits using the latest DNA technologies. Doing so will allow us to rapidly accelerate the development of new cultivars of coffee that can meet the challenges ahead. In December 2015, we initiated an important precursor of this work in Nicaragua, observing an F2 population of 350 coffee plants developed from a cross between MS1 and IAPAR59 to record how certain physical traits were or were not passed on from parent to child (phenotyping), and then

sequencing the DNA from the same samples to associate the observed traits with genetic markers in the plants (genotyping). As we accumulate more of this kind of data, breeders will become able to select parent plants based on their genetic makeup (which is easy and cheap to screen for using leaf samples) instead of waiting three to four years for the plant to mature. This can cut in half the time it takes to develop new cultivars.

Coffee leaf samples are collected in the field and then undergo DNA testing in a lab at Texas A&M University.

Adaptation to climate change

More crops worldwide are lost to drought and heat than any other stressors; drought is especially harmful to crops like coffee that require water at essential stages of their growth and development, like flowering. Droughts have become more frequent in coffee regions in recent years, and are expected to increase in number and severity this century. Scientists expect global arabica production to decline significantly in the next 20 years. The development of cultivars that are tolerant to drought and associated heat stress is essential to holding off these declines. To that end, a WCR postdoctoral fellow is working in Minas Gerais, Brazil to identify the molecular responses of coffee to these conditions in both the field and the lab. Another fellow is also working to identify key genes involved in drought and heat tolerance. Results so far show that approximately 1500 genes are involved in coffee's response to heat stress. Some of these genes are good candidates for future studies in coffee breeding, especially those aiming at the production of drought- and heat-tolerant plants.

Climate Change

Preparing for the future

As temperatures rise and extreme weather grows more frequent, Arabica coffee becomes increasingly susceptible to diseases, pests, and drought, while productivity and quality both fall. There is a widespread sense of urgency around helping coffee producers adapt to climate change to stave off the worst impacts, but there are major gaps in our knowledge of how to best do this.

World Coffee Research has an ongoing partnership with the International Center for Tropical Agriculture (CIAT) in Colombia to understand and map the predicted impact of climate change globally so that we can see which adaptation efforts will be most effective in different parts of the world.

In 2015, major work was completed to identify and and characterize five main agroecological zones suitable for coffee and their distribution around the world, as well as how those zones are expected to fare by 2050 (see p. 16).

But in order to really adapt to climate change, we need to understand the climate zones expected to become *unsuitable* for coffee in the future. Unsuitable conditions can range from desert-like environments in which it will be impossible to grow coffee to conditions that could be adapted for coffee with targeted efforts, such as planting drought-tolerant varieties, or increasing shade cover. Climate change may also allow new regions to be planted in coffee that were previously unsuitable.

Milestones in 2015

- We identified and characterized the five climatic zones suitable for coffee growing now and quantified the expected global losses by 2050. Our findings predict losses of up to 50% of currently suitable land globally. Published in PLOS One (see p. 16).

- We completed planning for phase II of a mapping study to classify zones predicted to be unsuitable in 2050 into the three categories: “lost,” “adaptable,” and “novel.” In 2016, we will map these zones globally, create specific adaptation strategies for marginal zones (e.g., switching to Robusta, adding irrigation, planting shade), and map their predicted success.

• In Brazil, we are developing of a partnership to screen the WCR Core Collection (see p. 30) and other planting material for their ability to tolerate drought and high temperatures. Complementary work at Texas A&M University is being undertaken to understand the physiological processes that allow some coffee varieties to be more drought tolerant that others, which will be incorporated into our coffee breeding efforts (see p. 30).

More crops worldwide are lost to drought and heat than any other stressors; drought impacts coffee quality and productivity. Photo: Carlos Borgonovo

Sensory Research Program

Improving coffee quality

The high quality specialty coffee market is the fastest growing part of the coffee sector. Improving the quality of coffee is essential to ensuring a sustainable future for the industry. Quality delivers higher prices for coffee producers and higher value for coffee drinkers. Improving the sensory qualities of coffee supports the growth of the specialty market as well as farmer livelihoods.

But in order to improve something, you have to be able to measure it. In the past measuring coffee's sensory qualities has not been a scientific or discriminatory affair. With the creation of the World Coffee Research Sensory Lexicon (see p. 13) we now have an essential new tool for describing coffee quality that is discriminatory, repeatable, and effective.

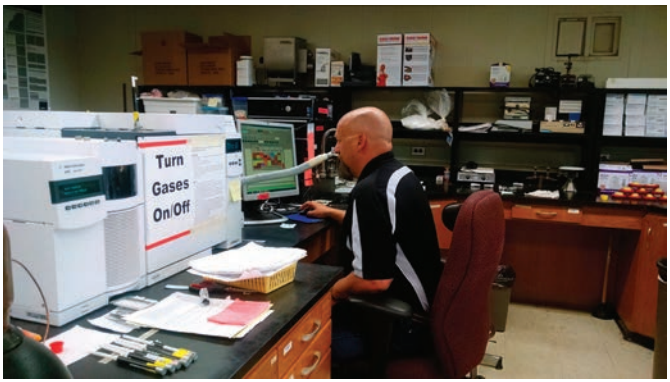
As such, in 2015, we began work on new tools and techniques that will help us unravel the sources of coffee's sensory qualities. With this set of new tools, we will be able to systematically evaluate a coffee sample's flavors and aromas and chemical makeup. We can correlate that data with its geographic and genetic origins, and over time will be able to predict quality based on these factors. We will be working to describe the most important volatile compounds in coffee and their causes, to build a library of samples and biochemical signatures, and to discover the genetic markers linked with key sensory attributes.

Milestones for 2015

- Working with multiple labs at Texas A&M University and Kansas State University, we created a system for evaluating many aspects of coffee quality for varieties from our research trials. When coffee is ready to be harvested from trial such as the International Multilocation Variety Trial (see p. 22) and our breeding program (see p. 30), it will be processed and roasted for evaluation. Samples will be tested to determine their flavors and aromas using the World Coffee Research Sensory Lexicon; for their precursor flavor/aroma volatile compounds using technology including gas chromatography and AromaTrax software; and for molecular and chemical components including caffeine content, chlorogenic acids, lipids, and terpenes.

• In Central America, we began the collection of 21 coffee varieties from 14 farms during the 2015-2016 harvest season, which will be fully analyzed in 2016. In total, 64 samples will be analyzed and they will be the first entrants into our reference library, which is expected to grow to hundreds in the next three years.

Scientists use gas chromotography and special software to separate and analyze chemicals related to coffee's aromas and flavors.



Kahawara Bora Ya Kivu

Democratic Republic of Congo

WCR is supporting a $6 million project to revitalize a once-great coffee region in the Democratic Republic of Congo. The project is led by Catholic Relief Services (CRS). To restore the coffee sector in Kivu, WCR is providing scientific and agronomic support to understand the main constraints to productivity and quality in the region.

Milestones in 2015

- A majority of farmers in the area use old varieties that are not well adapted to local conditions. To ameliorate this, ten variety demonstration plots were installed with local, high-performing cultivars (some from the Democratic Republic of Congo, and some from neighboring Rwanda). The plots show farmers how the use of improved varieties can help them produce more and better coffee.

- Through a survey of more than 100 farmers and subsequent statistical analysis of survey data, we found that most farmers in the region (65%) intercropped their coffee with beans. (Another 28% grow coffee in monoculture and 5% have "garden coffee.") On intercropped plantations, farmers were gradually losing large numbers of their trees. We discovered the main reason for this is that beans are grown too close to the coffee plant. When farmers hoe the beans, they inadvertently damage the roots of their coffee trees. These results and others are guiding technical advice and training strategies with an emphasis on respecting a "no-bean circle" around the coffee trees as well as densification of coffee plots.

- The Democratic Republic of Congo signed on as a participant to the International Multilocation Variety Trial. Twenty-eight of the world's best arabica coffees cultivated worldwide were shipped to an INERA research site, and will be planted in fields in 2016. Congo's participation in the trial lays the basis for the use of elite planting material by the country in the medium and long terms, and also includes the country in an important international scientific network.

New raised drying beds in South Kivu. Photo: Michael Sheridan, CRS

WHAT'S AHEAD

In 2016, we expect to continue delivering essential research to support the growth of quality coffee and farmer livelihoods, including:

- An expanded focus on climate change, climate-smart agriculture, and breeding climate-resilient coffees

- The execution of an international network of on-farm demonstration trials with new varieties and soil treatments

- A variety catalog for Central America (with comprehensive sensory evaluations using the Sensory Lexicon) and the background research to develop a variety catalog for Africa.

- The launch of the Verified pilot program to ensure that coffee nurseries are producing healthy, genetically pure plants

- The development of new molecular genetics tools for breeding the next generation of coffee varieties

- Continued work on the International Multilocation Variety Trial

- A focused sensory project linking key taste attributes to their volatile compounds and precursor molecules.

- A major collaborative program with the Global Crop Diversity Trust to conserve coffee's endangered genetic resources, forever.

YOU'RE INVITED!

WCR GENERAL ASSEMBLY

Friday, April 15, 4:00-5:30 pm
Georgia World Congress Center, Room C201
Atlanta @ SCAA Event

In 2016, we will launch a yearlong strategic planning effort to create the research agenda for our second five-year phase (2017-2021). All of our members are invited to join us for a General Assembly to learn more about our work so far, and give feedback on WCR's future research.

YOUR INVOLVEMENT

"Members of WCR support the long-term supply of quality coffee and the lives of the people producing it. After 40 years in this industry we know that our future is intertwined with the supply chain and it is both our responsibility and in our self-interest to do our part."—Andrew Bowman, Tony's Coffee

CHECK-OFF PROGRAM

Roasters can support our work by contributing half a penny per pound ($.005/lb.) of green coffee purchased through participating importers. Importers can partner with us to administer contributions from roasters and can also become direct donors by offering matching contributions. Sign up at worldcoffeeresearch.org

DIRECT INVESTMENT

Please contact Hanna Neuschwander directly at hanna@worldcoffeeresearch.org

INTRODUCING WCR SERVICES

Coffee Genetic Testing

WCR is pleased to announce its first fee-for-service program for the coffee industry. Coffee samples can be submitted for genetic fingerprinting to determine or verify the variety.

Who is the service for?

- Nurseries that want to be certain what type of coffee they are selling
- Farmers or other plant buyers (e.g., coffee development project managers) who want to be sure of what they are buying
- Coffee farm buyers who want to verify the type of existing plants on the farm
- Importers/exporters/roasters who are looking for a specific variety because of cup profile, or who want to verify that shipped coffees match pre-shipment samples

Cost: $85/sample

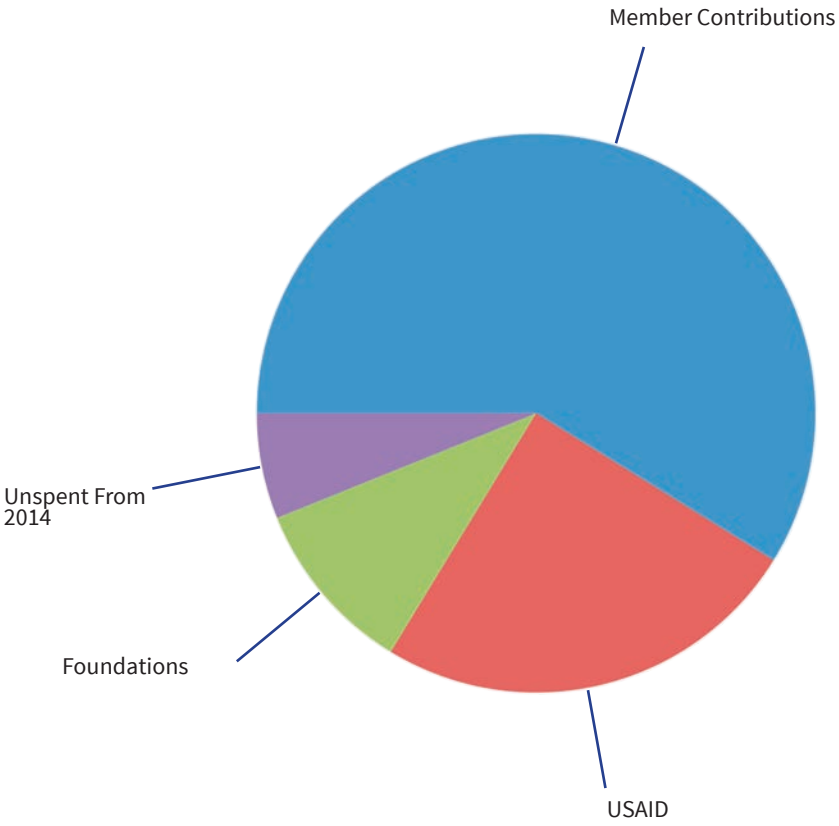
If you are interested in submitting samples, please contact World Coffee Research at info@worldcoffeeresearch.org. We will follow up within one week with sample preparation instructions.

Coming 2016—Sensory Analysis

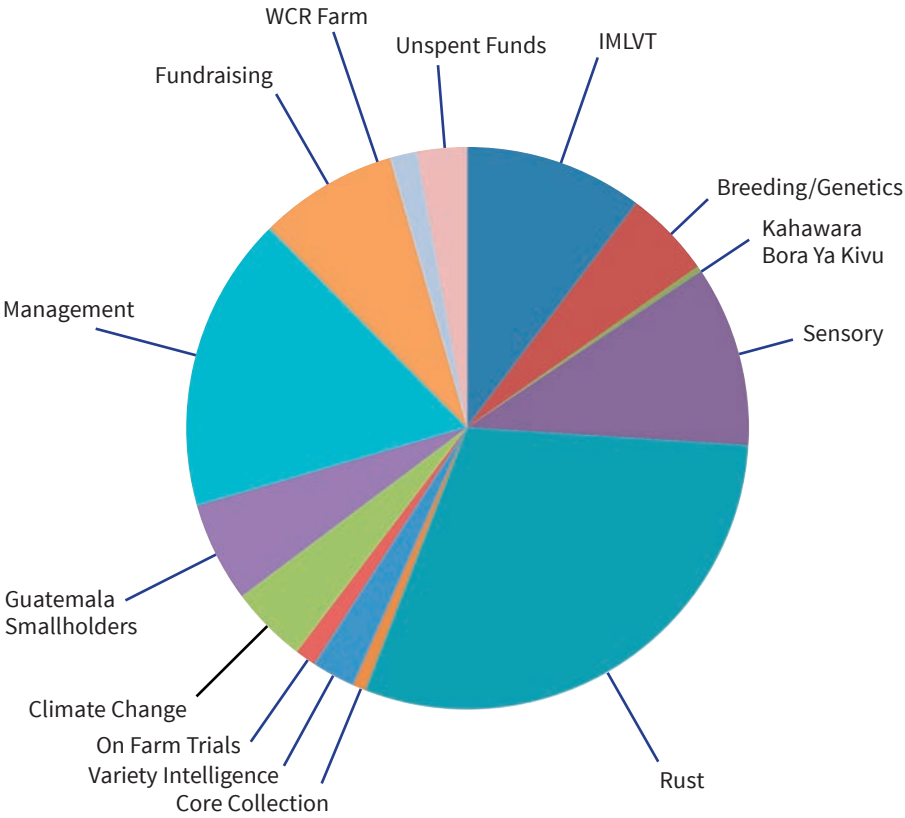
In 2016, we will launch a sensory analysis service for roasted or green coffee samples using the new World Coffee Research Sensory Lexicon.

FINANCIAL STATUS REPORT

2015 REVENUE
$2,367,883



2015 EXPENDITURES BY PROGRAM
$2,367,883



STAFF

Our core scientific and administrative staff apply their expertise in coffee, genetics, plant science and diseases, and sensory science to create and execute an ambitious research agenda.

Tim Schilling, Executive Director
Leo Lombardini, Deputy Director
Christophe Montagnon, Scientific Advisor
David Laughlin, Coffee Rust Project Director
Benoit Bertrand, Coffee Breeder
Trish Klein, Molecular Geneticist
Hanna Neuschwander, Communications Director
Iris Romero Gonzales, WCR Farm Manager
Siaska Castro, Administration and Finance Director
Dana Lewis, Program Coordinator
Daniel Dubon, Data Manager

GRADUATE STUDENTS AND FELLOWS

Researchers and graduate students from around the world are working on problems and projects identified as essential by World Coffee Research core scientific staff.

Bárbara Castanheira Ferrara Barbosa, postdoctoral fellow, Department of Horticultural Sciences, Texas A&M University
Gladyston Rodrigues Carvalho, postdoctoral fellow, Department of Horticultural Sciences, Texas A&M University
Fabián Echeverría Beirute, Ph.D. student, Department of Soil and Crop Sciences, Texas A&M University
Taya Brown, Ph.D. student, Horticultural Sciences, Texas A&M University
Lauren Fedenia, Ph.D. student, Horticultural Sciences, Texas A&M University
Marco Branciari, M.S. student, Agricultural Science and Technology, University of Bologna, Italy

BOARD OF DIRECTORS

Our board members are some of the most important leaders and thinkers from coffee companies around the world. They work hard behind the scenes to guide our programs.

Brett Smith, Counter Culture Coffee (Chair)
Tracy Ging, S&D Coffee and Tea, Inc. (Vice Chair and Secretary)
Shawn Hamilton, Java City (Treasurer)
Ric Rhinehart, Specialty Coffee Association
Lindsey Bolger, Keurig Green Mountain Coffee
Mike Keown, Farmer Brothers/Coffee Bean International
Furio Suggi Liverani, illycaffè
Tanya Lomax, Mars Drinks
James McLaughlin, Intelligentsia Coffee and Tea
Vincent Petiard, Nature Source Genetics (ex-officio)
Ben Pitts, Royal Cup Coffee
Ed Price, Center on Conflict and Development
Matt Saurage, Community Coffee Company
Jim Trout, The J. M. Smucker Company
Doug Welsh, Peet's Coffee & Tea

MEMBERS

Our members—companies and organizations large and small—help set the global agenda for coffee research. Their support is the foundation for a vibrant and sustainable coffee sector.

Platinum
Keurig Green Mountain Inc.
Mars Drinks
The J.M. Smucker Company

Gold
Allegro Coffee Company
Community Coffee Company
Counter Culture Coffee
Farmer Brothers/Coffee Bean International
illycaffè
Intelligentsia Coffee & Tea
Java City
Mercon Coffee Group
OLAM Specialty Coffee
Peet's Coffee & Tea
Royal Cup Coffee
S&D Coffee Roasters
Taylors of Harrogate

Silver
Atlas Coffee Importers
Batdorf & Bronson Coffee Roasters
Bontain Coffee
Cafe Fadie (Kyokuto Fadie Co., Ltd.)
Dunn Brothers
Gavina
Genius Coffee
Hacienda La Minita
InterAmerican Coffee
Japan Roasters Network
La Marzocco International, LLC
Old City Coffee
Pacific Espresso
Philz
Reunion Island Coffee
RGC Coffee
Rose Park Roasters
Salt Spring Coffee

Specialty Coffee Association of Japan
Sweet Maria's Coffee
Swiss Water Decaffeinated Coffee Company, Inc
Terarosa (Haksan Co Ltd)
Toa Coffee Co. Ltd.
Tony's Coffee
Union Hand-Roasted Coffee
Walker Coffee Trading

ADDITIONAL SUPPORT

Howard G. Buffet Foundation
Starbucks Foundation
USAID

AFFILIATED ORGANIZATIONS

ACE Alliance for Coffee Excellence
CQI Coffee Quality Institute
ICO International Coffee Organization
NCA National Coffee Association
SCAA Specialty Coffee Association of America
SCAJ Specialty Coffee Association of Japan
SCAE Specialty Coffee Association of Europe

PARTNERS

ACO The African Coffee Organization/ Research and Development
ACRN African Coffee Research Network
AFCA Africa Fine Coffees Association
APLU American Public Land Grant Colleges and Universities
ANACAFE Guatemalan National Coffee Association
EMBRAPA CAFÉ Brazilian Coffee Research Consortium
CABI Centre for Agricultural Bioscience International
CATIE Tropical Agricultural Research and Higher Education Center
CIAT International Center for Tropical Agriculture
CIRAD French Agricultural Research Centre for International Development
CRI Coffee Research Institute, Kenya
Global Coffee Review (WCR Media Partner)
HARC Hawaii Agriculture Research Center
ICCRI Indonesian Coffee and Cocoa Research Institute
IITA Agricultural Research for Development in Africa
Indian Coffee Board Research and Development
INECOL Institute of Ecology, Mexico
INERA National Institute for Agricultural Research, Democratic Republic of Congo
Ministry of Agriculture and Irrigation, Peru
Peruvian National Coffee Board
PROMECAFE – Regional Cooperative Program for the Technical Development and Modernization of Coffee Culture
Royal Botanic Gardens, Kew
San'a University, Yemen
UCB Catholic University of Bukavu, Democratic Republic of Congo
USDA Coffee Research Program
Federal University of Viçosa, Brazil

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