ARRCC
Asia Regional Resilience to a Changing Climate

Developing Wheat Rust Early Warning Systems for South Asia

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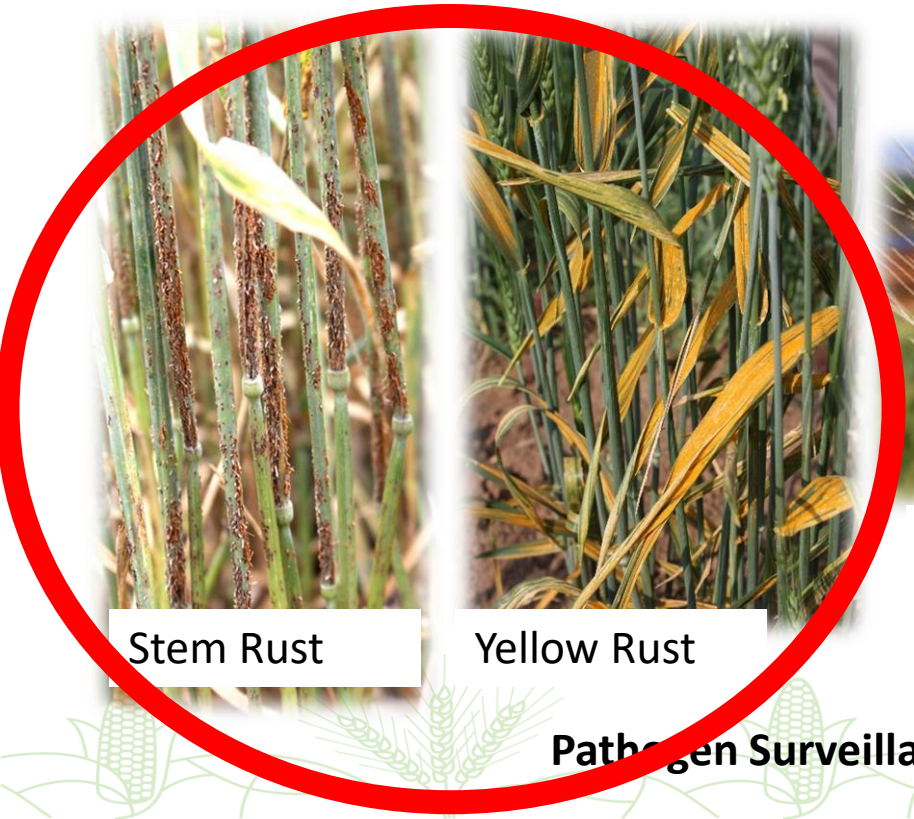
An Increasing Threat – Transboundary Pathogens & Pests

- **Rate of spread, appearance in new areas, detection of new races (new diseases) is increasing**
  - Drivers: Globalization (trade, travel), uniform cropping systems, climate change


Stem Rust

Yellow Rust


Wheat Blast

Maize Lethal Necrosis


Fall army Worm

Pathogen Surveillance & Monitoring Systems increasingly needed.

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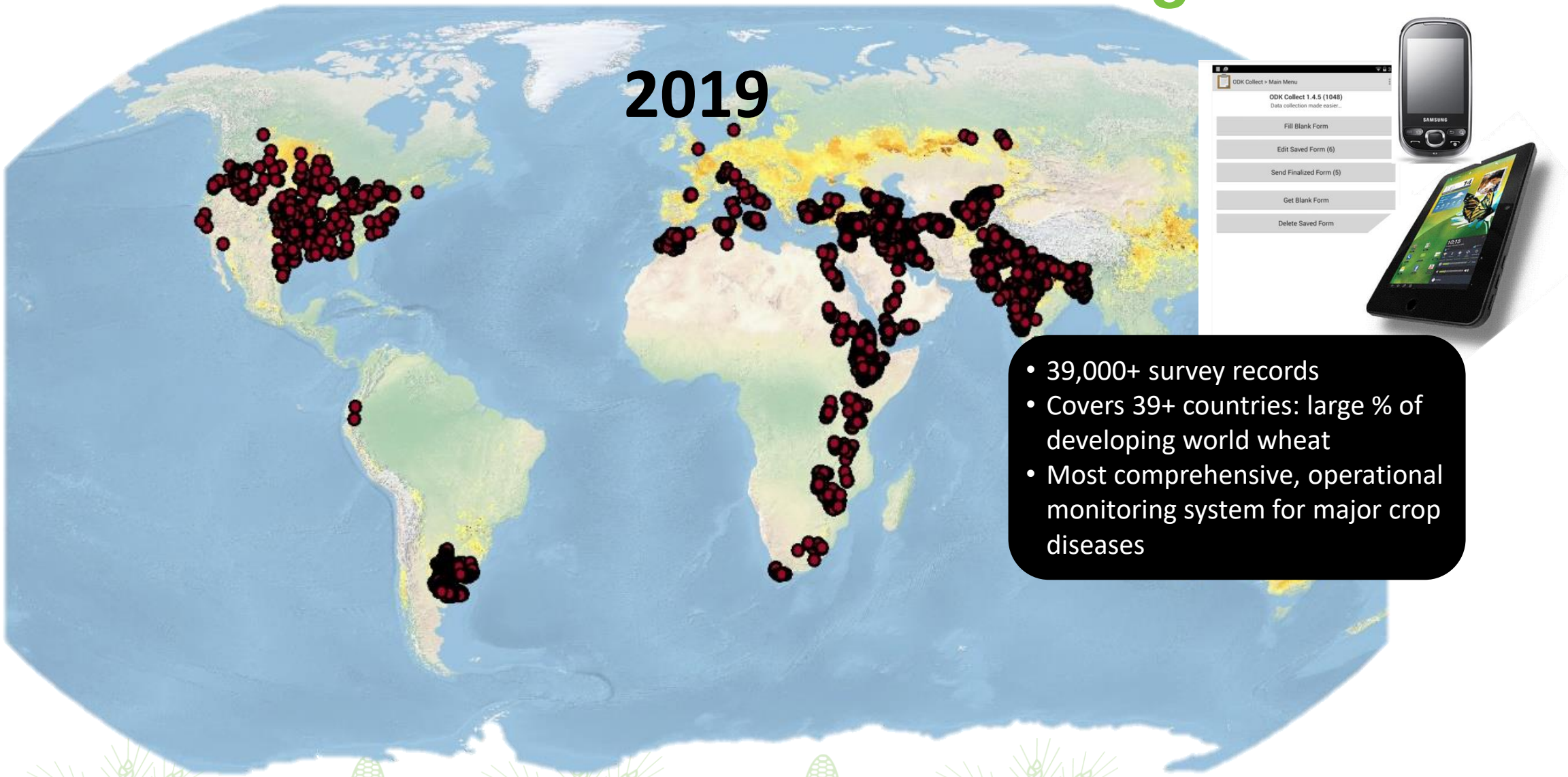
Global Wheat Rust Monitoring



- 39,000+ survey records
- Covers 39+ countries: large % of developing world wheat
- Most comprehensive, operational monitoring system for major crop diseases

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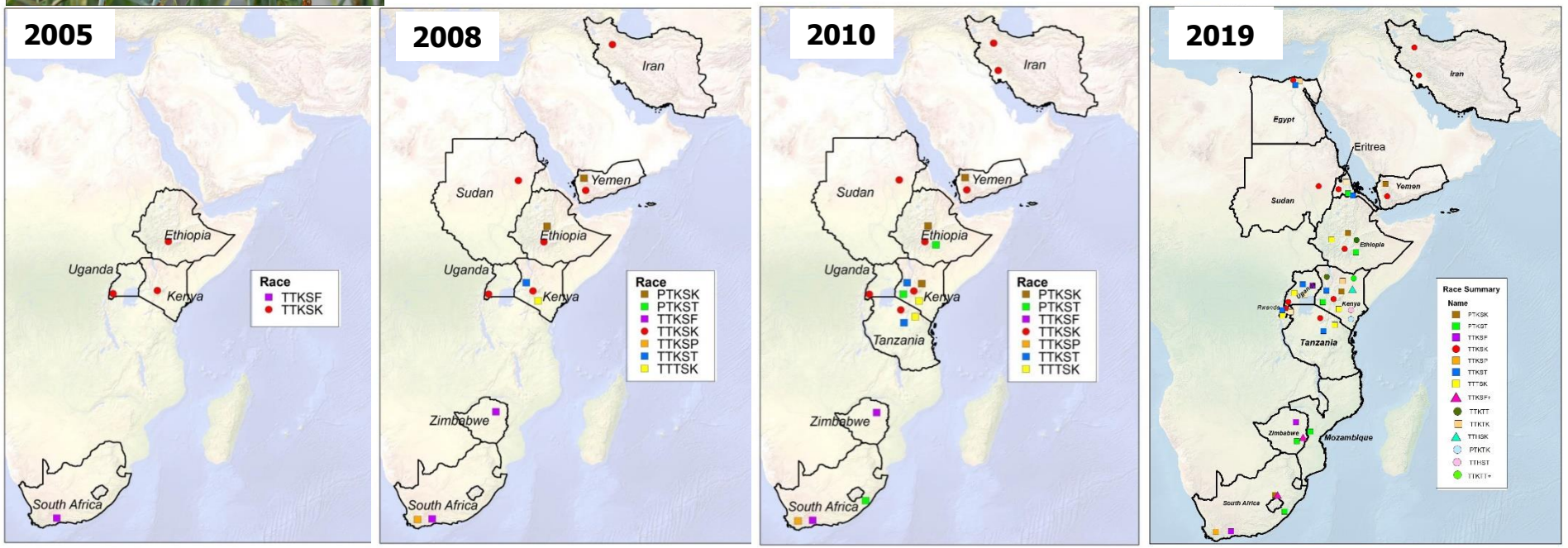
Evolution and spread of races belonging to Ug99 lineage of stem (black) rust fungus



- Ug99 is mutating and migrating
- Fourteen Ug99 races now known. Presence in 13 countries confirmed
- 80-90% wheat varieties/germplasm susceptible or with inadequate resistance in 2006
- Global stem rust threats now extend beyond Ug99

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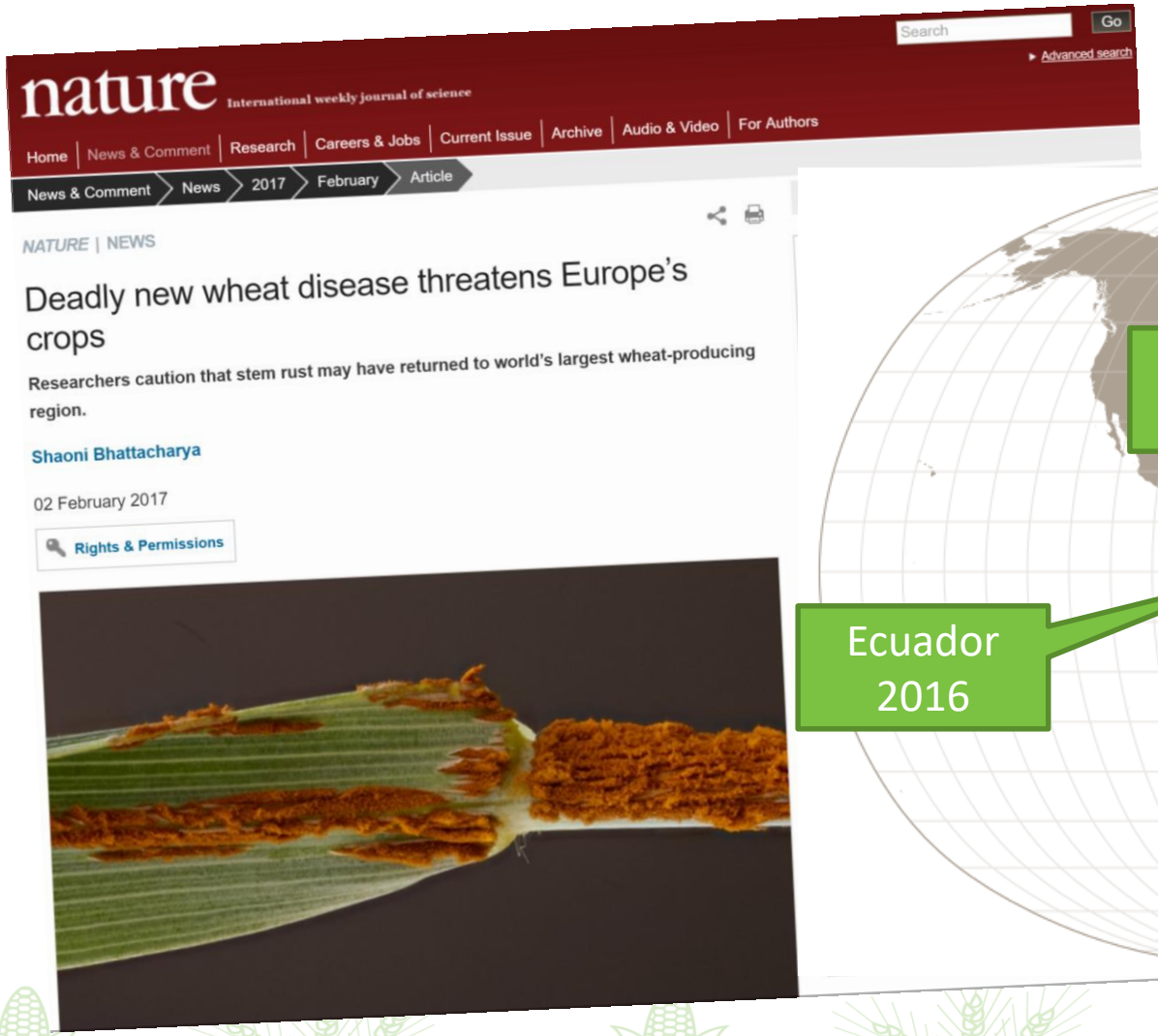
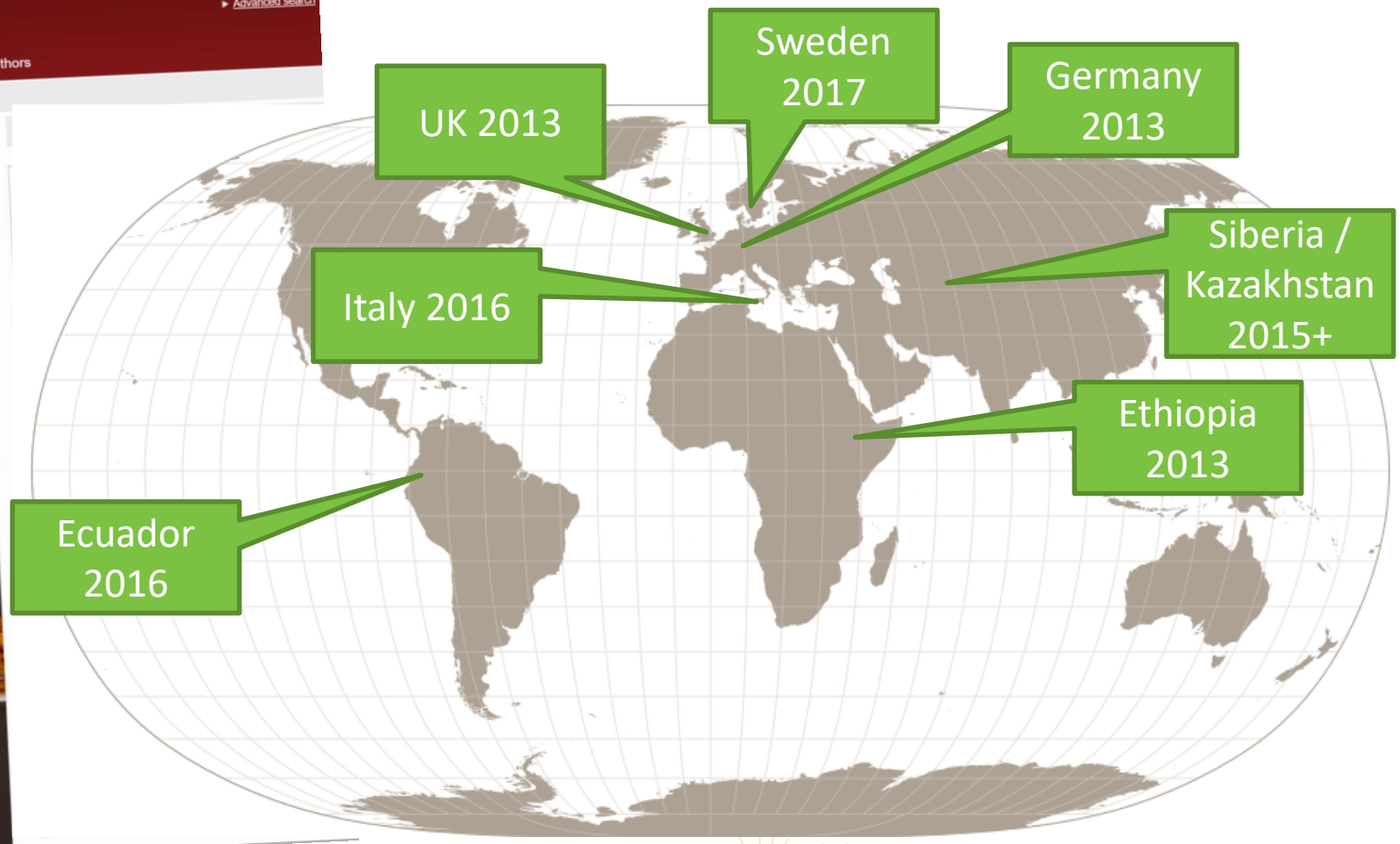
Re-emerging Stem Rust (Non Ug99)





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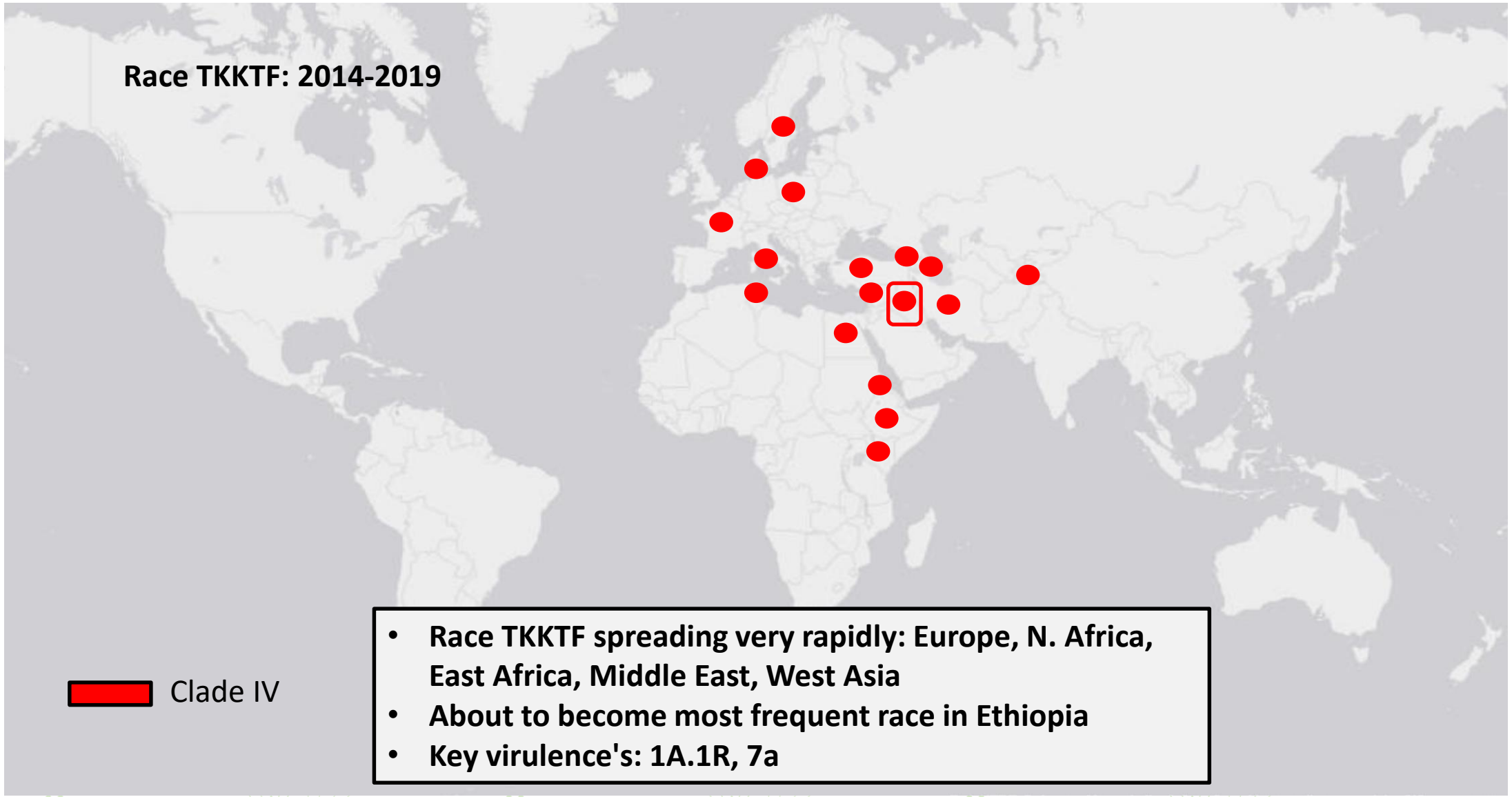
Stem Rust: Race Groups of Concern (Non Ug99)



- **Race TKKTF spreading very rapidly: Europe, N. Africa, East Africa, Middle East, West Asia**
- **About to become most frequent race in Ethiopia**
- **Key virulence's: 1A.1R, 7a**

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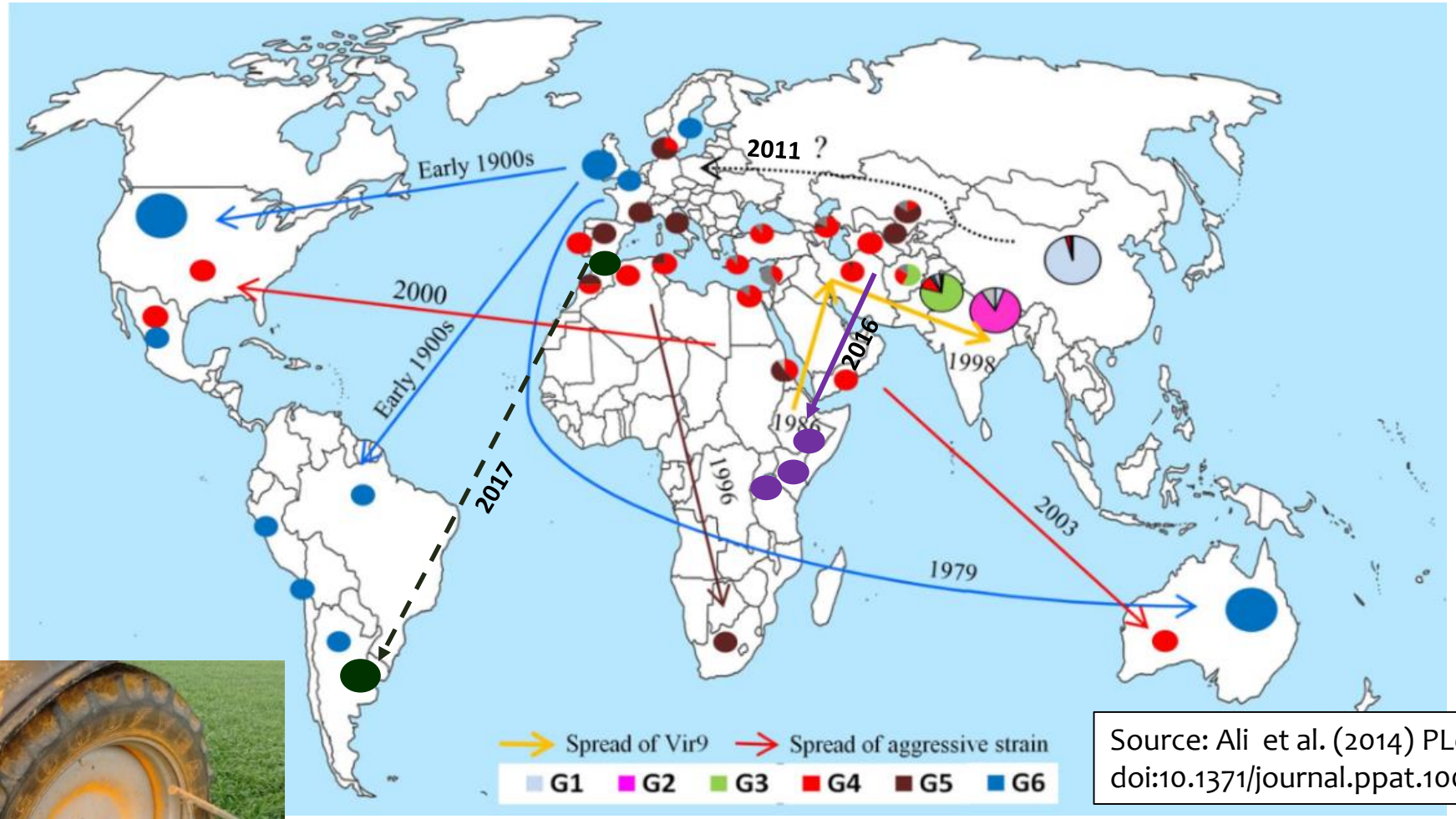
New races of wheat rust fungi spreading across the globe and into new areas; an example of stripe (yellow) rust



Source: Ali et al. (2014) PLoS Pathog 10(1): e1003903. doi:10.1371/journal.ppat.1003903 (updated)

East Africa and Himalayan region considered important sources

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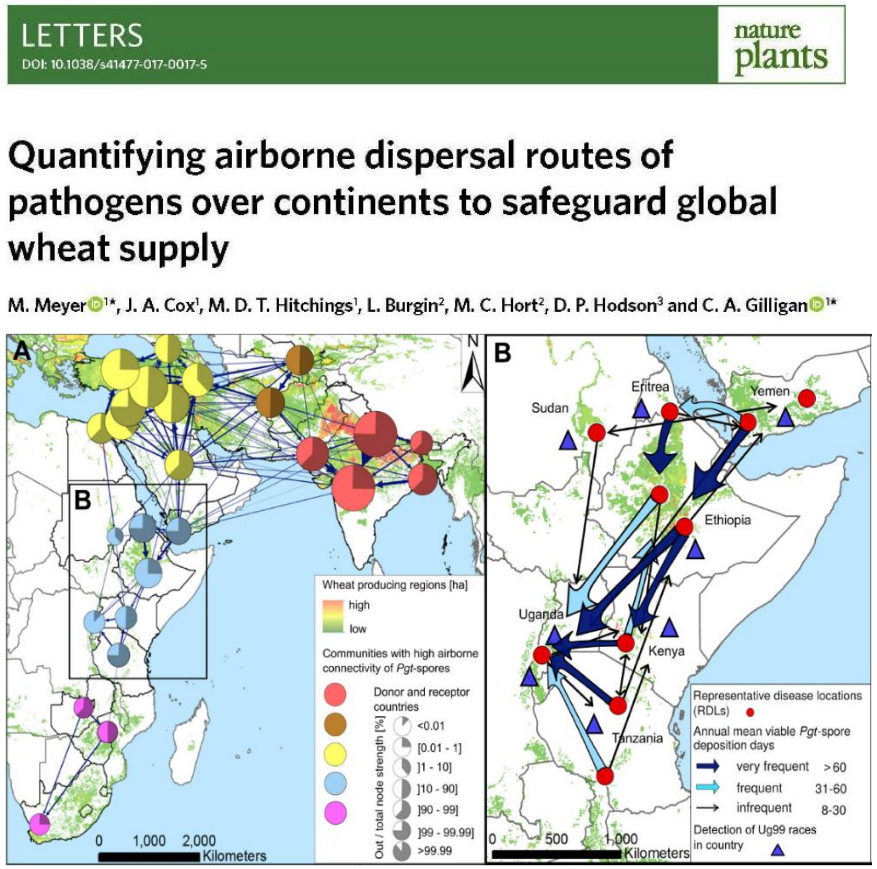
Advanced Stem Rust Spore Dispersal Modelling - Rust Early Warning Systems

- Advanced Spore Dispersal Model (NAME model, UK Met Office)
- **First quantitative estimates** of spore dispersal to different regions and continents
- Models give a **risk assessment framework** e.g., how likely stem rust to move into South Asia?
- **Real-time forecasting** part of an early warning system – Ethiopia
- **Predicting many of movements we now seeing globally**



Meyer et al 2017 Nature Plants

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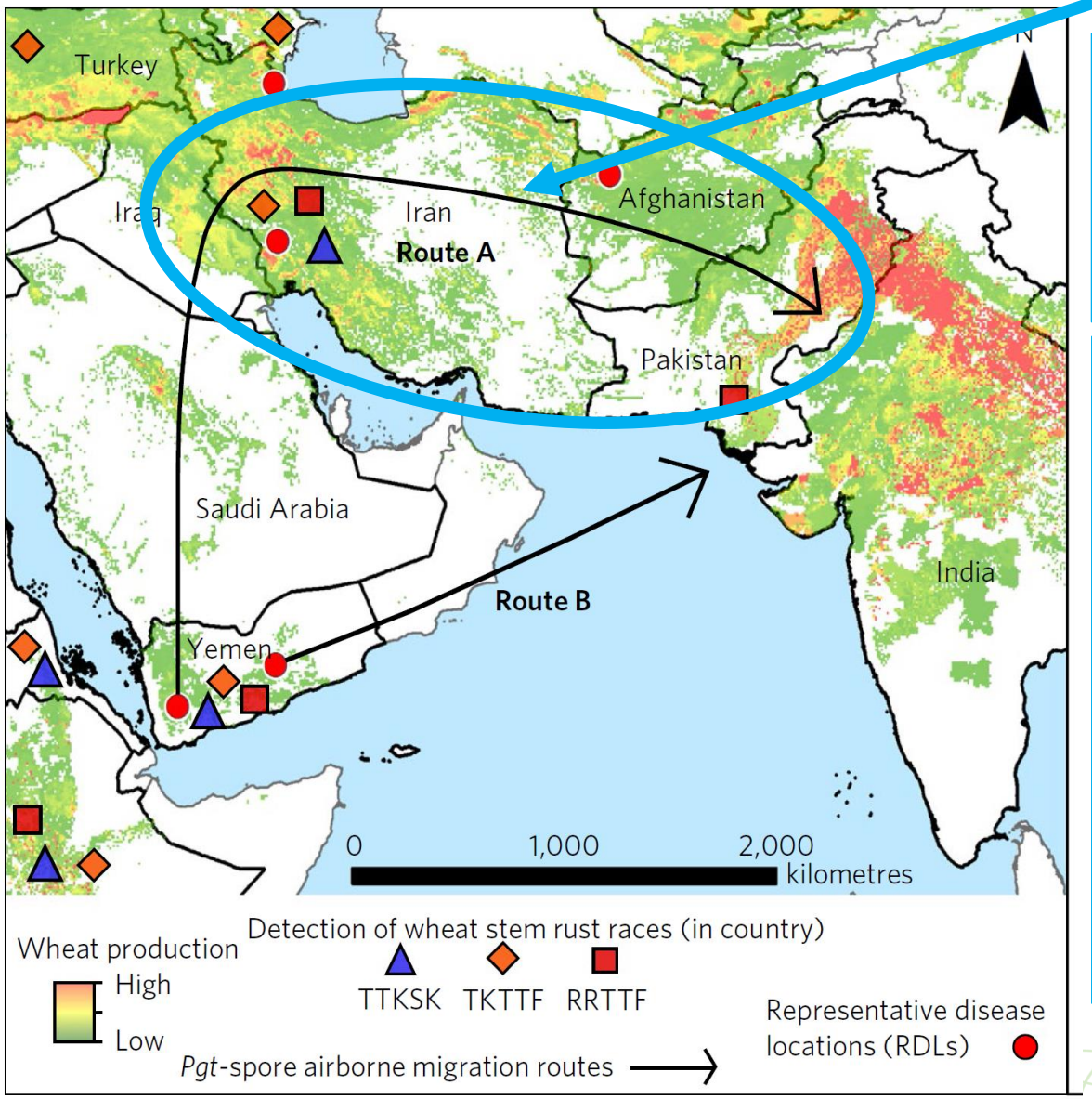
How Likely Stem Rust Incursions to South Asia?

Meyer et al 2017 Nature Plants

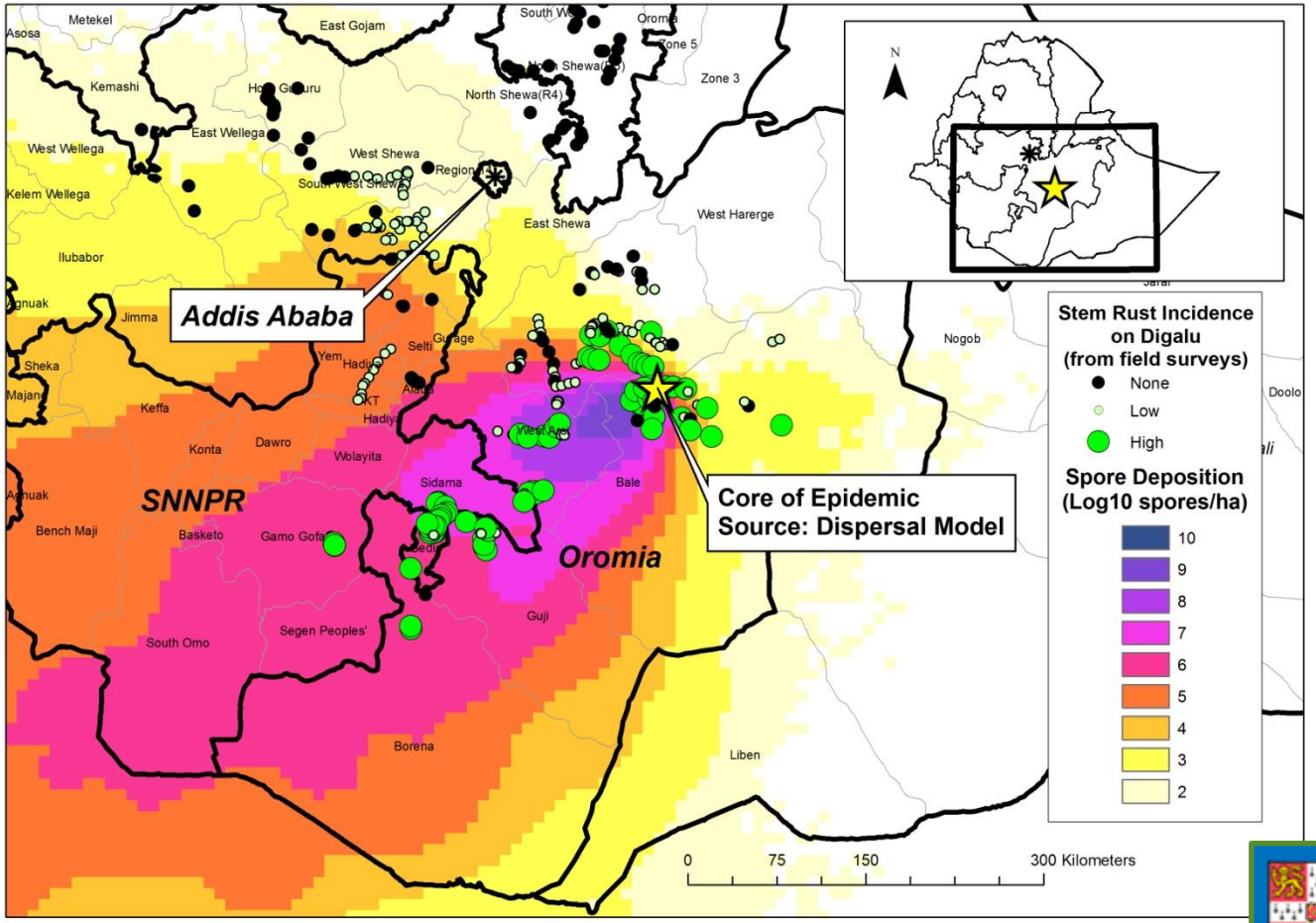


Route A

- **Small outbreak** (<1000ha) in Iran (Ug99 to date)
- = **Zero Probability** direct transport to Pakistan & India

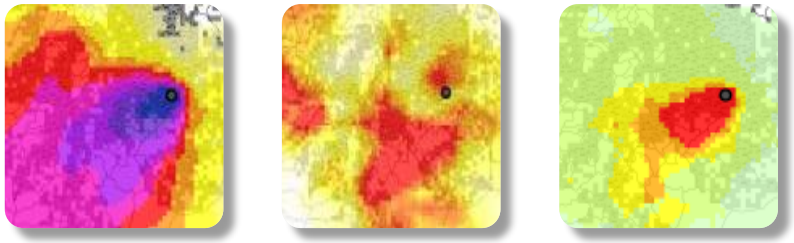
- **Moderate to large outbreak** (>1000ha, >15% Incid/sev) in Iran
- = **Rare/Infrequent direct** transport to Pakistan & India
- = **Frequent / Very Frequent indirect transport** to Afghanistan – then to Pakistan/India
- Short time window: Mar/April

Spore dispersal and disease environmental suitability forecasting



- Advanced Spore Dispersal Model (NAME model, UK Met Office)
- 7 day forecast models for dispersal and risk (daily, in-season)

Dispersal + Suitability → Risk



Olivera et al., 2015 Phytopathology
Meyer et al 2017 Nature Plants

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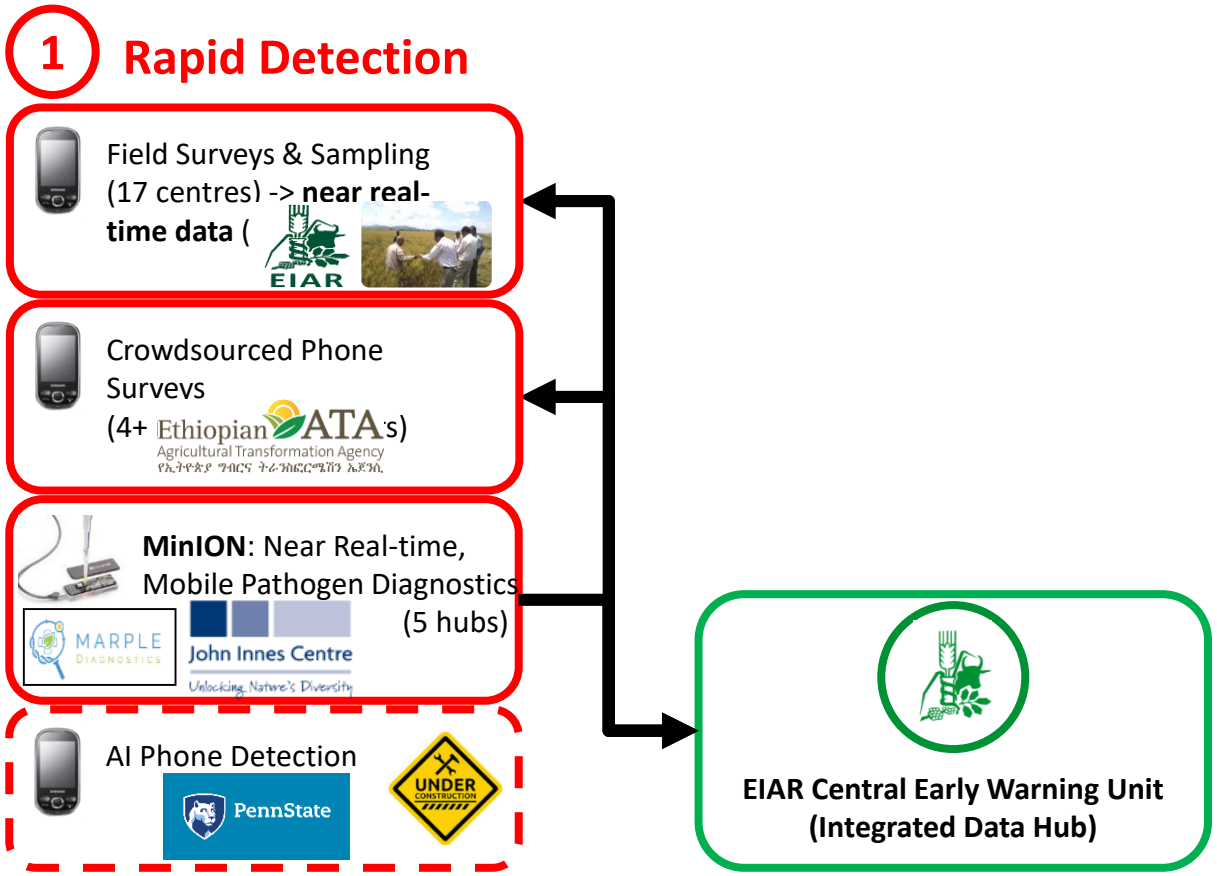
Allen-Sader et al., 2019,
Env Res Letters

Overview of wheat rust EWS, Ethiopia



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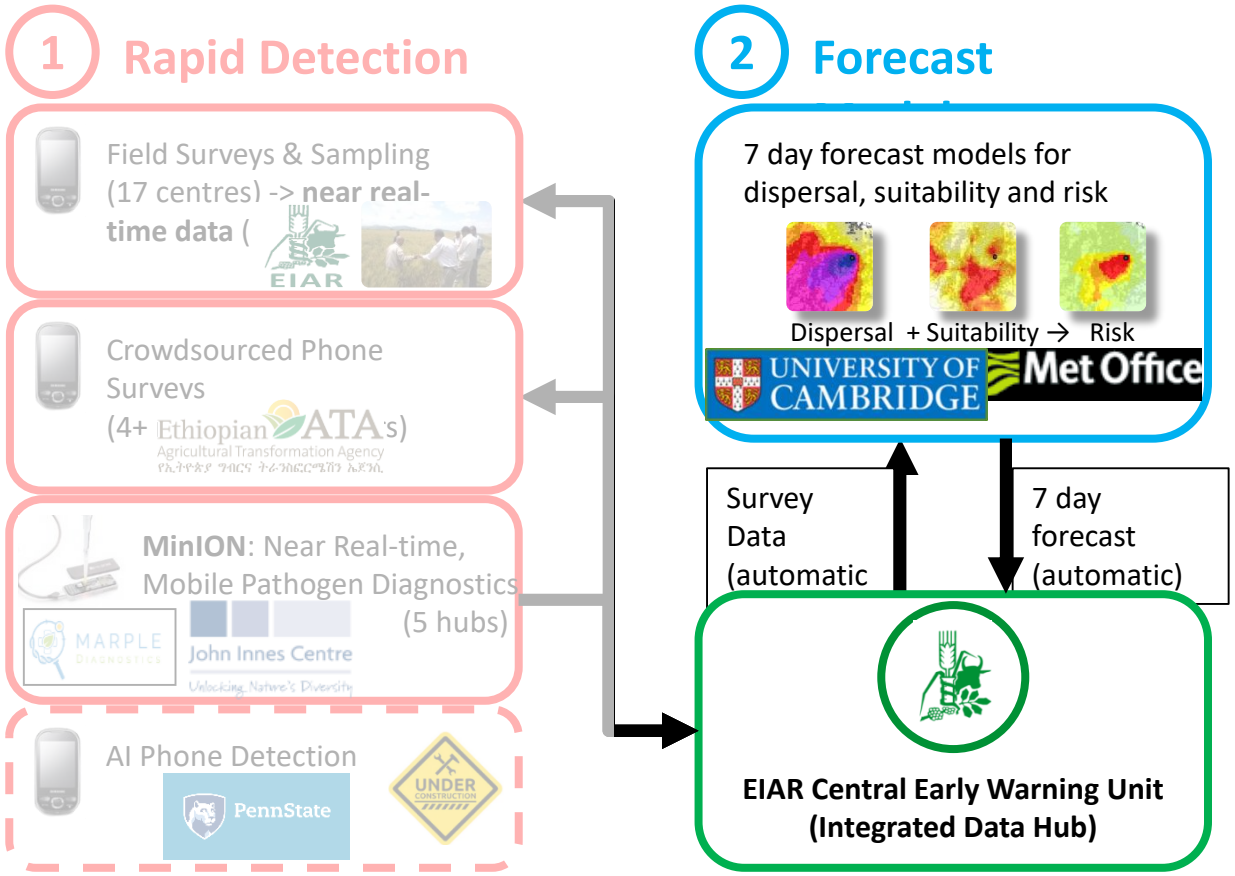
Allen-Sader et al., 2019,
Env Res Letters

Advanced forecast models deliver automatically a 7 day forecast of risk



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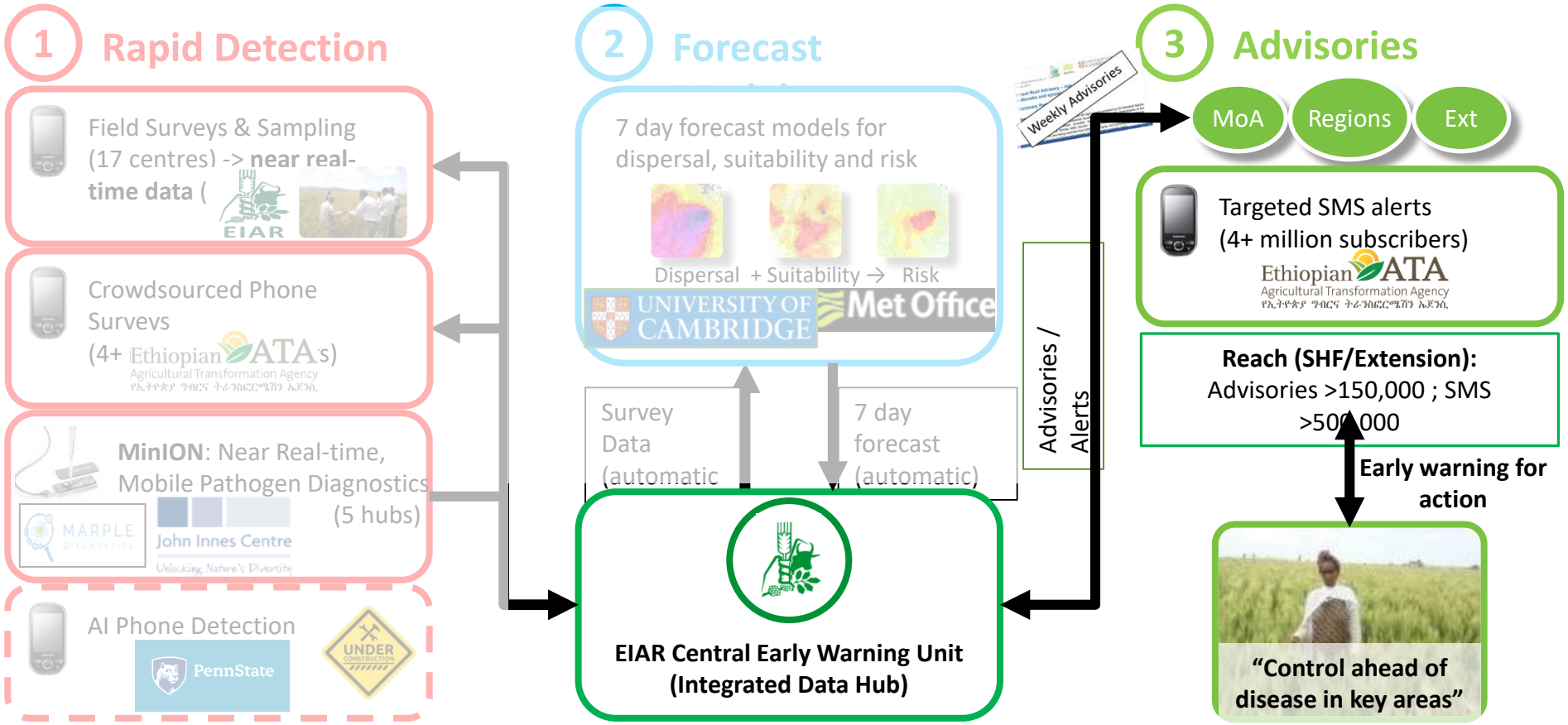
Allen-Sader et al., 2019,
Env Res Letters

Weekly advisories and alerts are sent out to key authorities and farmers.



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South Asia: Early Warning and Advisory for Key Wheat Diseases

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- Initial 1 year pilot phase (Nov 2019 – Dec 2020)
- Planned additional phases: +2 years
- Focus: Bangladesh + Nepal (but includes regional aspects)
- Key Diseases: Wheat rusts + wheat blast

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Key Objectives

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- Test and transfer meteorologically-driven dynamic epidemiological forecasting models for wheat rust from Ethiopia (models developed and successfully implemented) to Nepal and Bangladesh.

- Preliminary assessment of potential for forecasting wheat blast dispersal

- Use the models to predict disease spread and to inform disease management programmes in collaboration with research, extension and meteorological agencies in Nepal and Bangladesh.

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Initial ARRCC Activities – South Asia

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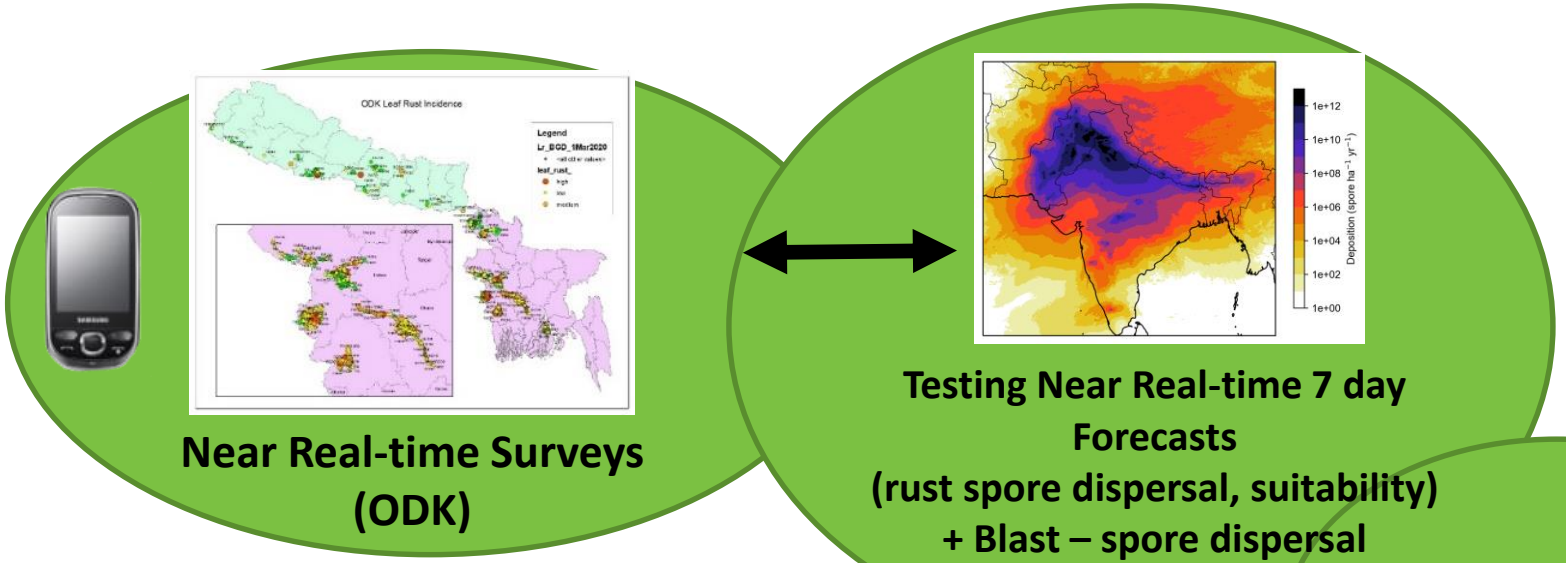

Near Real-time Surveys (ODK)

Testing Near Real-time 7 day Forecasts (rust spore dispersal, suitability) + Blast – spore dispersal

In-country Expert Assessment

Forecast Advisory / Alerts to Farmers / Extension (2021 Season)

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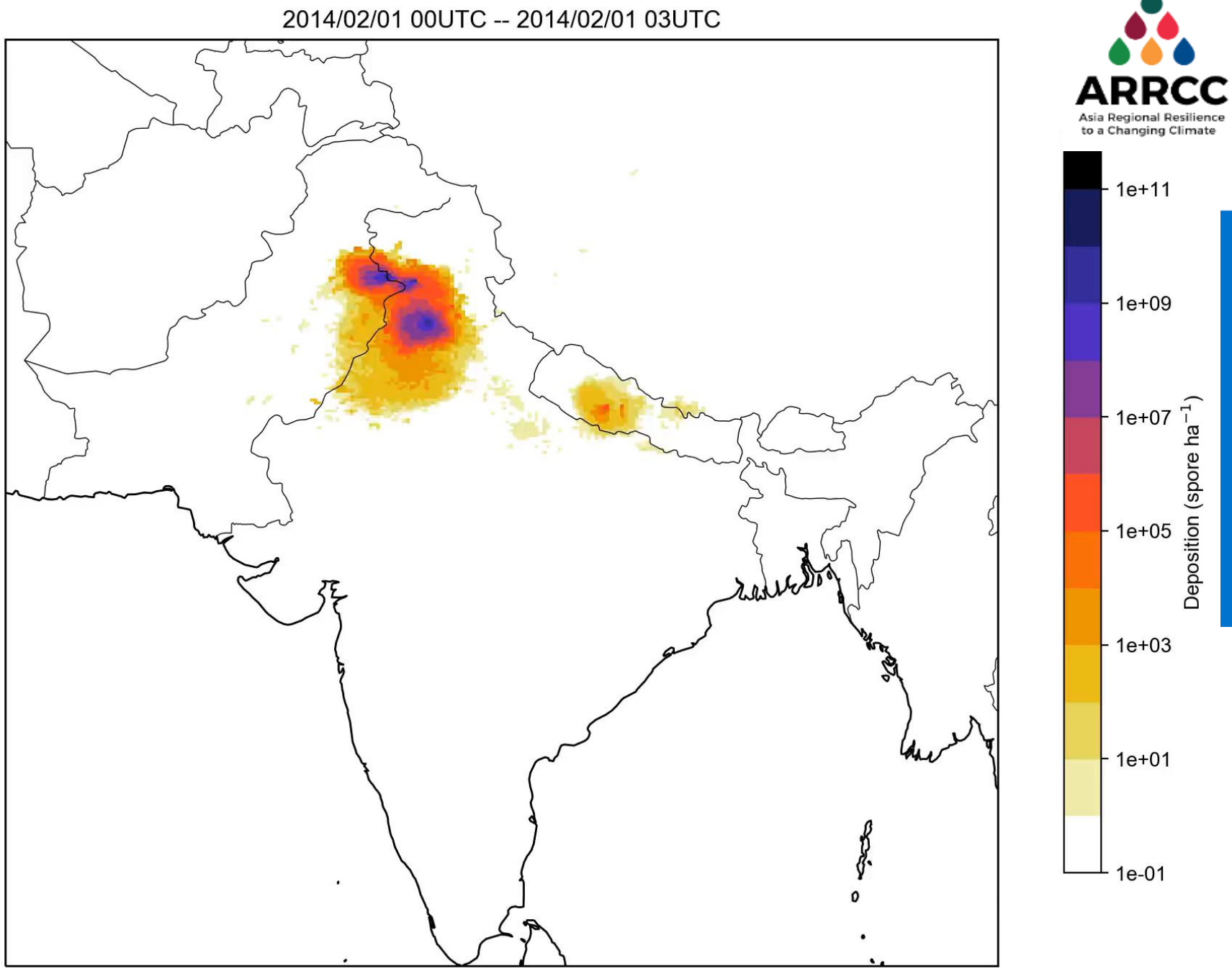
Dispersal models – improved knowledge of spore movements and regional connectivity

Example animation: Stripe rust spores, February 2014



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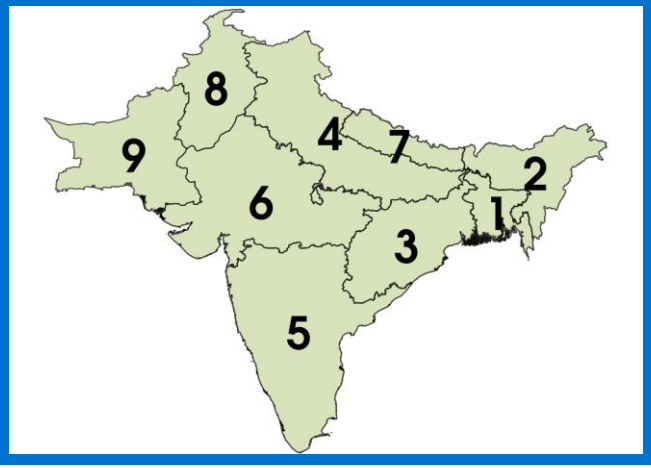
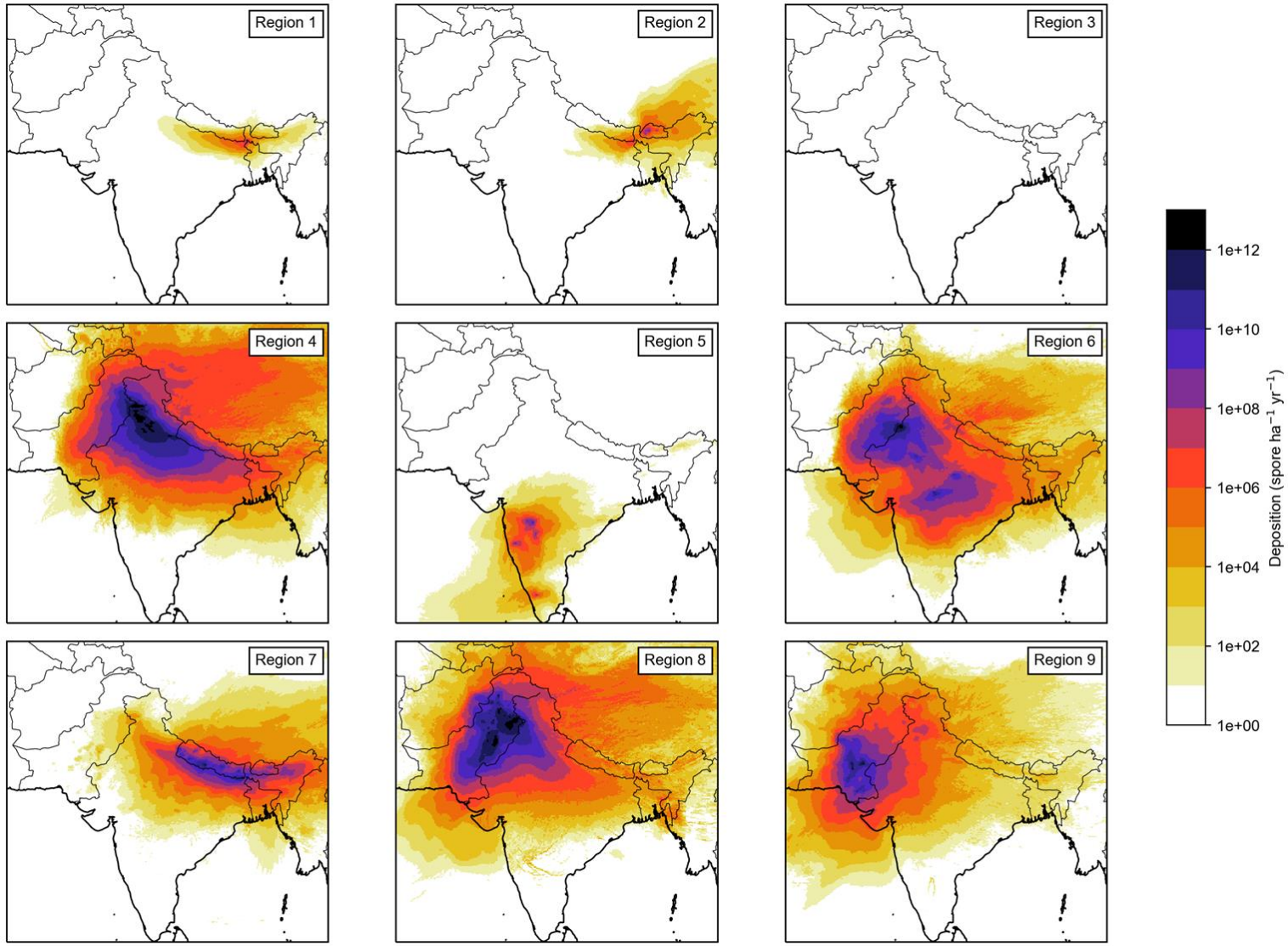
Annual cumulative spore deposition by source region (2011-2018 average)
Stripe rust

Influence of sub-regions





ARCC Progress - Highlights

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- Better understanding of regional connectivity, dispersal patterns – based on historical survey data + models
- Model forecast pipeline implemented by Cambridge University and UK Met Office, fully functional since first week of Feb 2020. 7 day forecasts
- Leaf rust, incorporated in the forecast system (1st time)
- Extensive field surveys in 2020 (Nepal & Bangladesh)
- Automated data harvesting and mapping tool based on media reports of rust outbreaks developed by CIMMYT-Bangladesh
- Expert groups formed in Bangladesh & Nepal
- Draft advisories developed in Nepal & Bangladesh. Pre-season advisories now being disseminated in both Nepal & Bangladesh
- Strong alignment has been observed with the forecast model outputs
- Wheat Blast: Linkages to Empraba / UPF modellers. Testing of dispersal parameters for wheat blast

Automated Data Gathering Tool - Rust Reports

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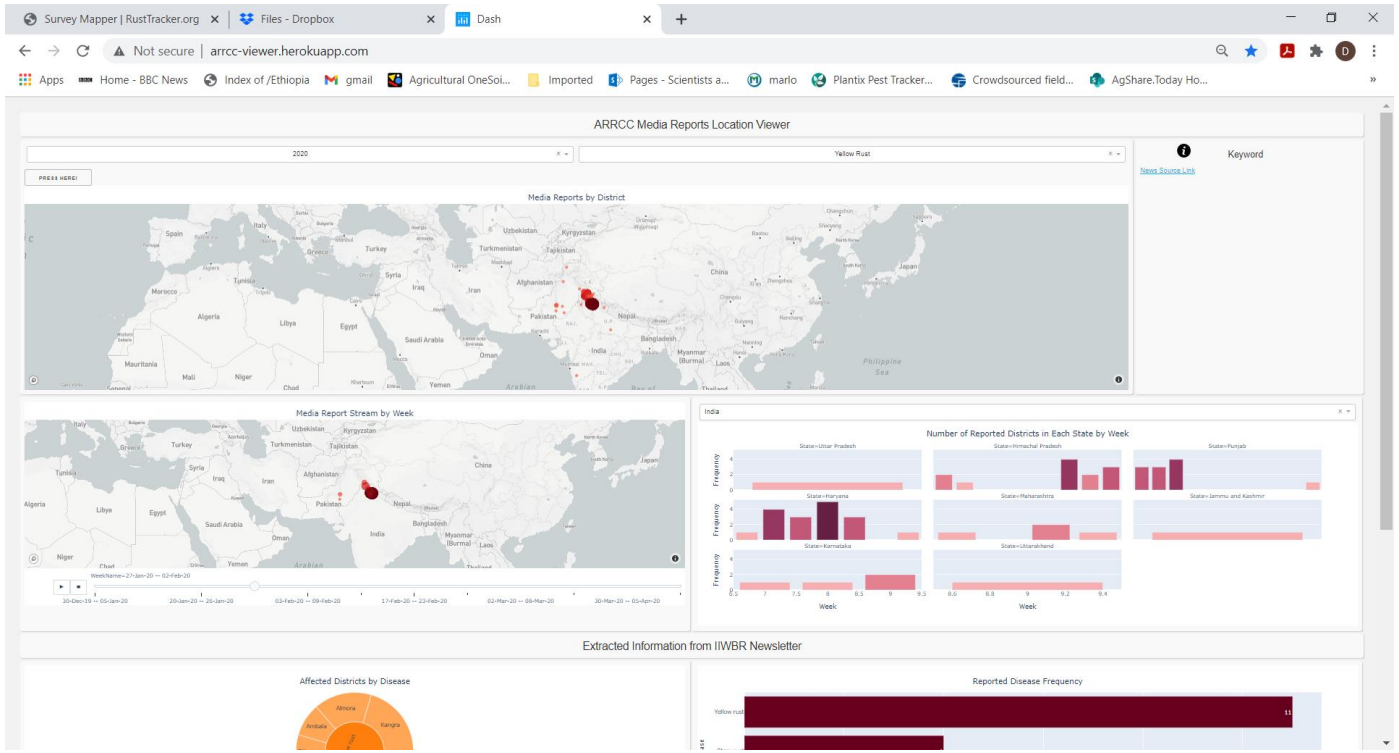
- Automatically extracts reports of rusts in media / newsletters
- Potential additional source of outbreak information for forecasts / follow up surveys



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Promising Initial Forecast Results

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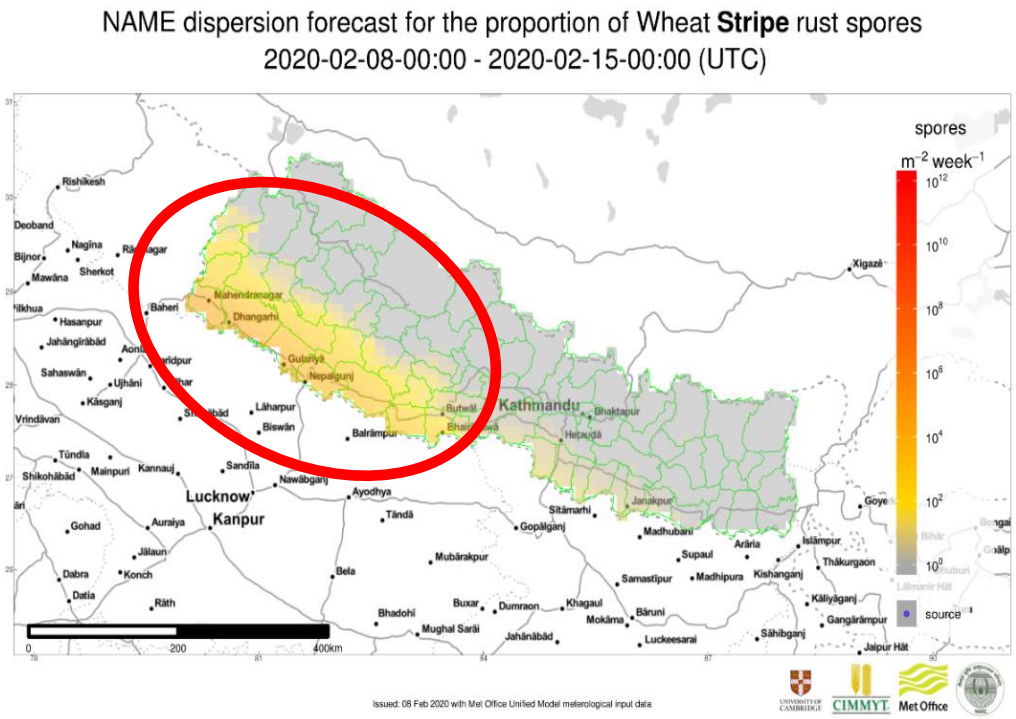
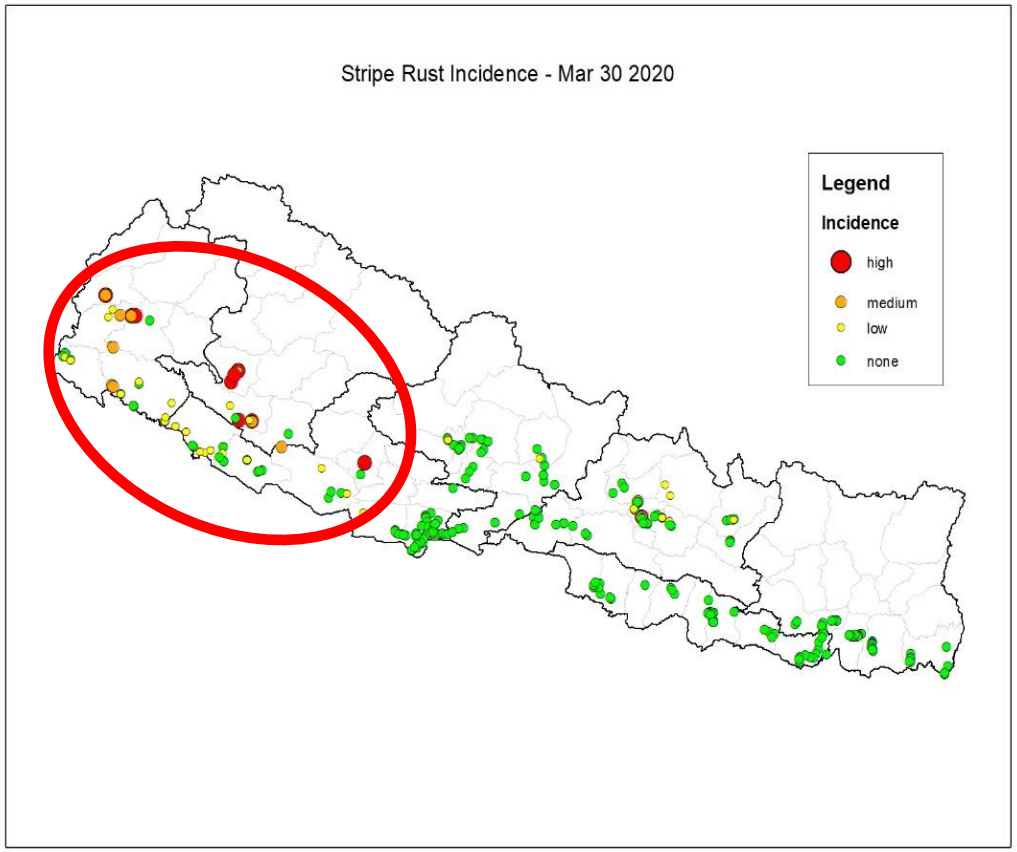
Model Forecast – early Feb



Potential new stripe rust race 238S119 – Incursion from India ?? (TBC)

Actual disease occurrence – late March



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Summary

- Long-term global rust surveillance + monitoring implemented
- Development of an operational early warning and advisory system in Ethiopia
- Testing and transfer of early warning and advisory systems to South Asia
- Forthcoming season – expand near-real time surveillance to Afghanistan and Pakistan to improve regional forecasts + deploy advisory's to farmers in Bangladesh & Nepal (target 50k farmers)

Acknowledgements

- AAFC, Winnipeg, Canada
- ATA, Ethiopia
- Cambridge University, UK
- CIMMYT
- CRIFC, Turkey
- DRRW / Cornell University
- IIWBR, Shimla, India
- EAAPP
- EIAR, Ethiopia + RARI's
- Ethiopian MoA + Regional BoA's
- FAO
- Global Rust Reference Centre, Denmark
- ICARDA
- John Innes Center, UK
- KALRO, Kenya
- PBI, University of Sydney, Australia
- Penn Sate University
- Sathguru Management Consultants
- UCL, Louvain, Belgium
- UK Met Office
- University of the Free State, South Africa
- University of Minnesota
- USDA-ARS Cereals Disease Laboratory, MN

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