Global Occurrence and Economic Consequences of Stripe Rust in Wheat

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CIMMYT International Maize and Wheat Improvement Center

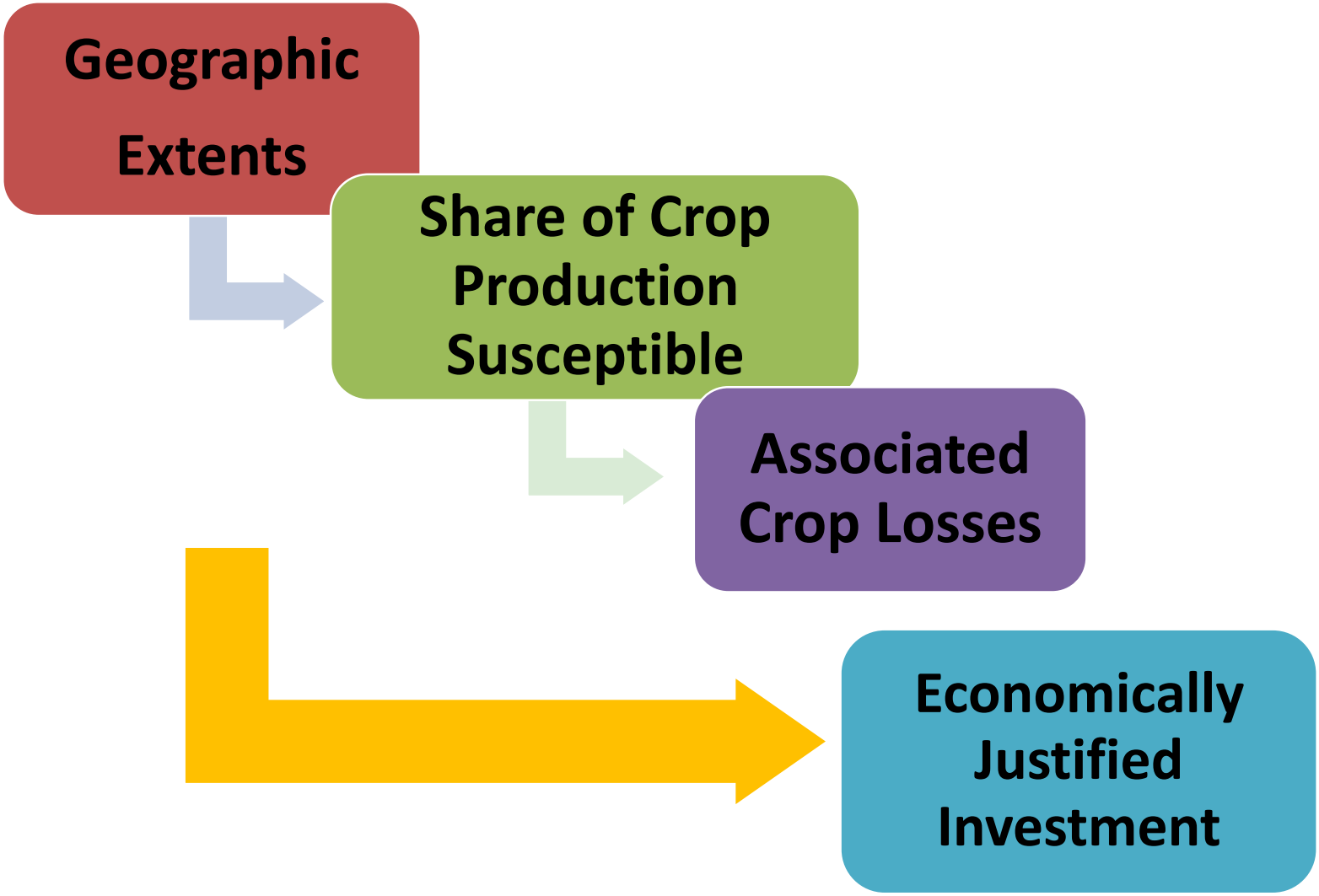
BGRI Borlaug Global Rust Initiative

INSTEPP International Science & Technology Practice & Policy, University of Minnesota

HarvestChoice

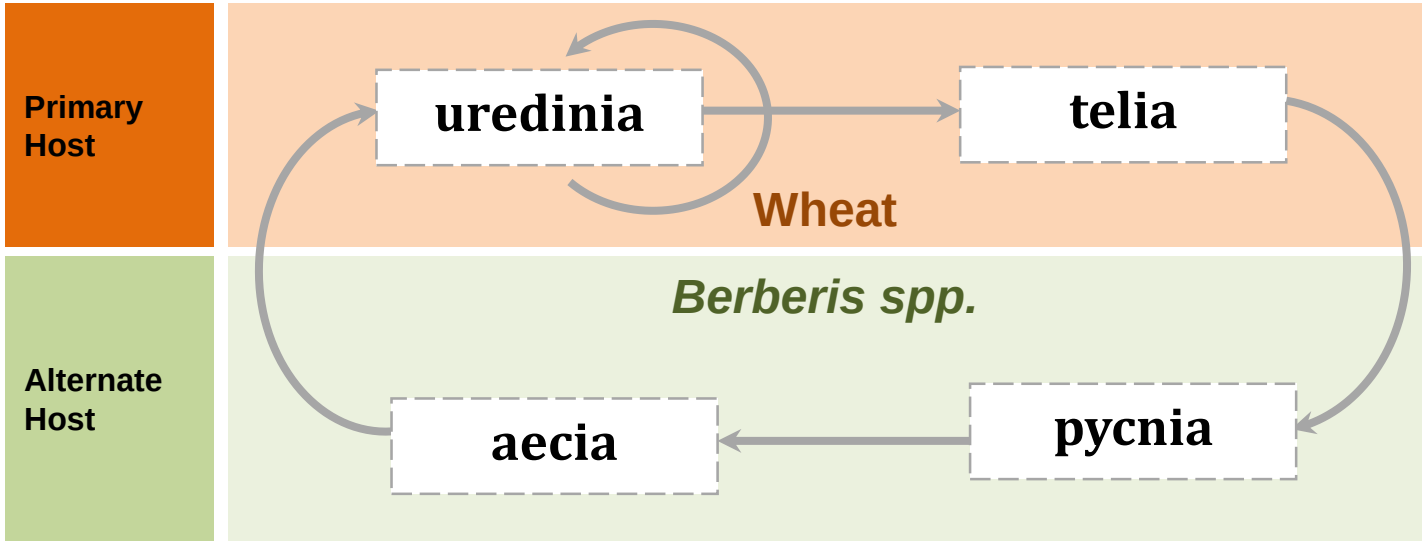
CSIRO

Policy Questions regarding Crop Diseases

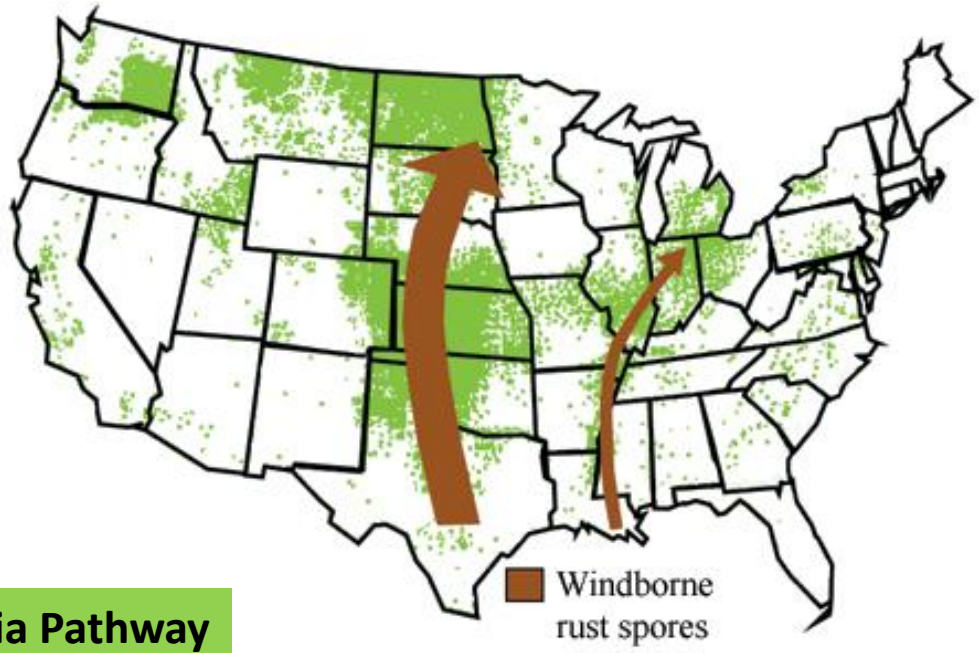


Wheat Rust Diseases

Disease Cycle



Wind Dispersal



Puccinia Pathway

Source: USDA CDL

Wheat Rust Diseases

Extent	• Occurring almost all wheat growing countries • Spreading across continents
Frequency	• Increasing frequency in the last decade
Impact	• Stem Rust Ug99 • Stripe Rust Yr9 and Yr27




Photo source: CIMMYT

Science POLICYFORUM

AGRICULTURE

Right-Sizing Stem-Rust Research

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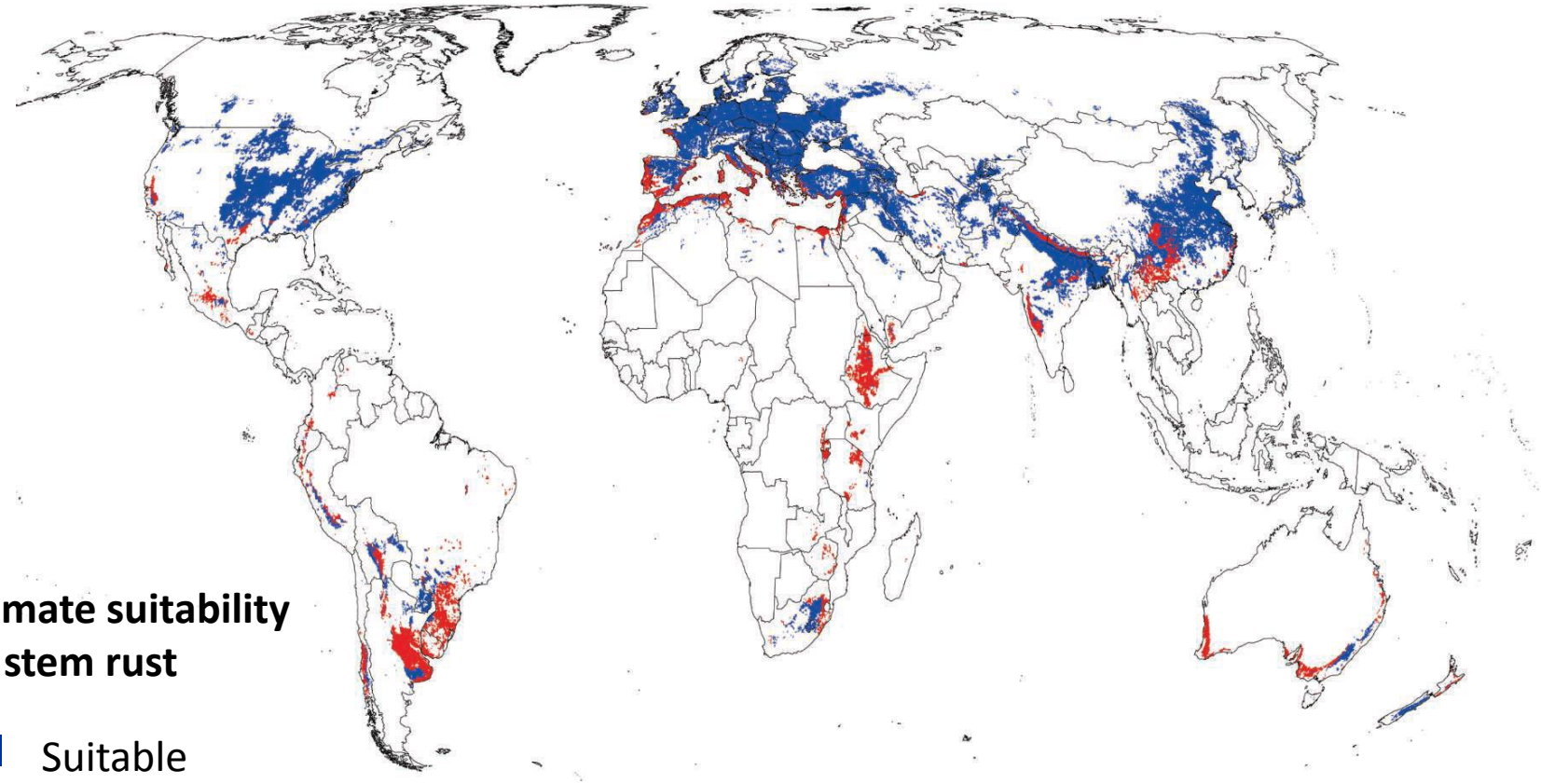
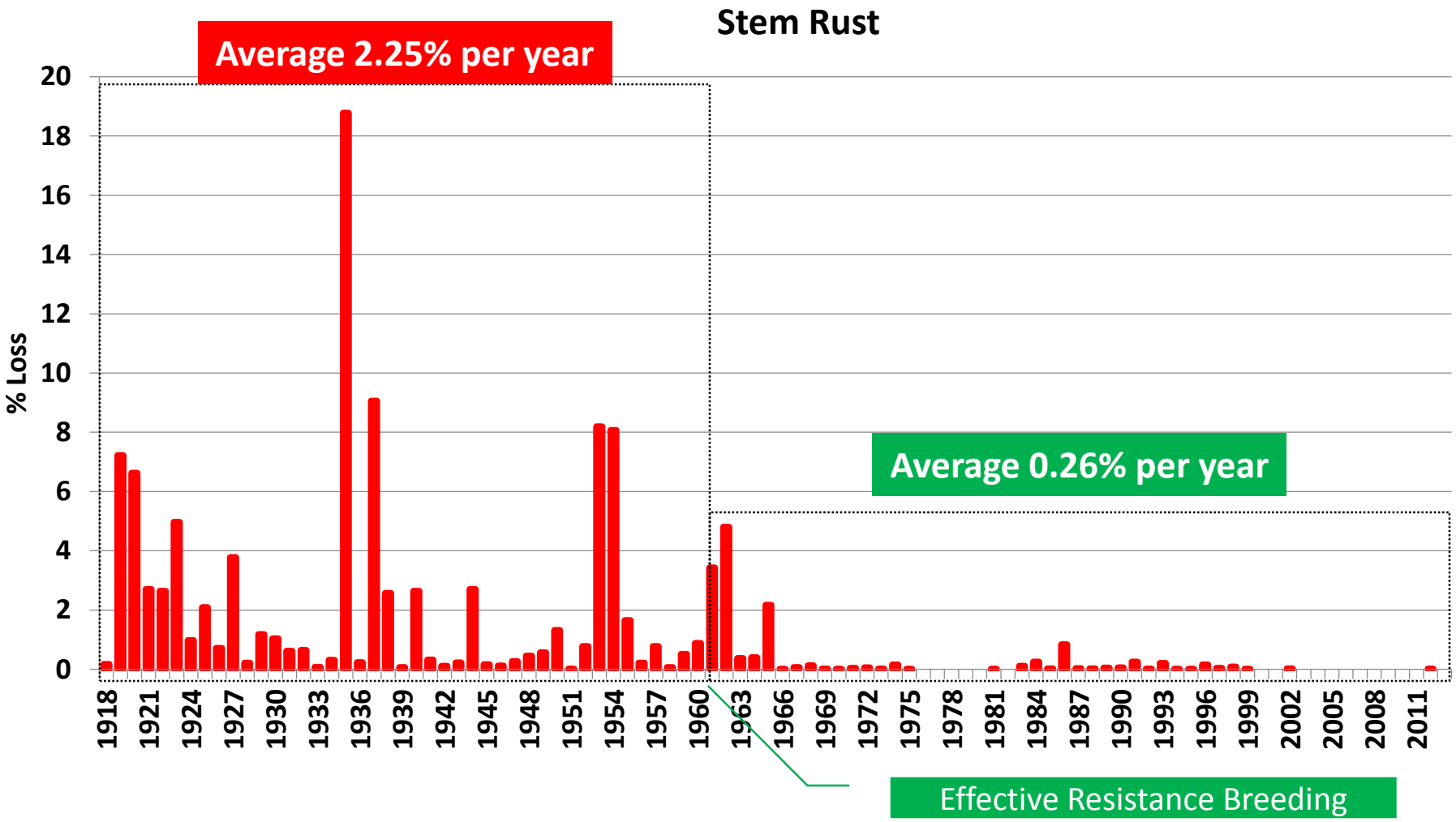
Is increased support needed for wheat disease research to avert crop losses from current and future strains?



Climate suitability of stem rust

- Suitable
- Persists

Stem Rust Losses in the U.S.



Author's calculation based on USDA CDL data

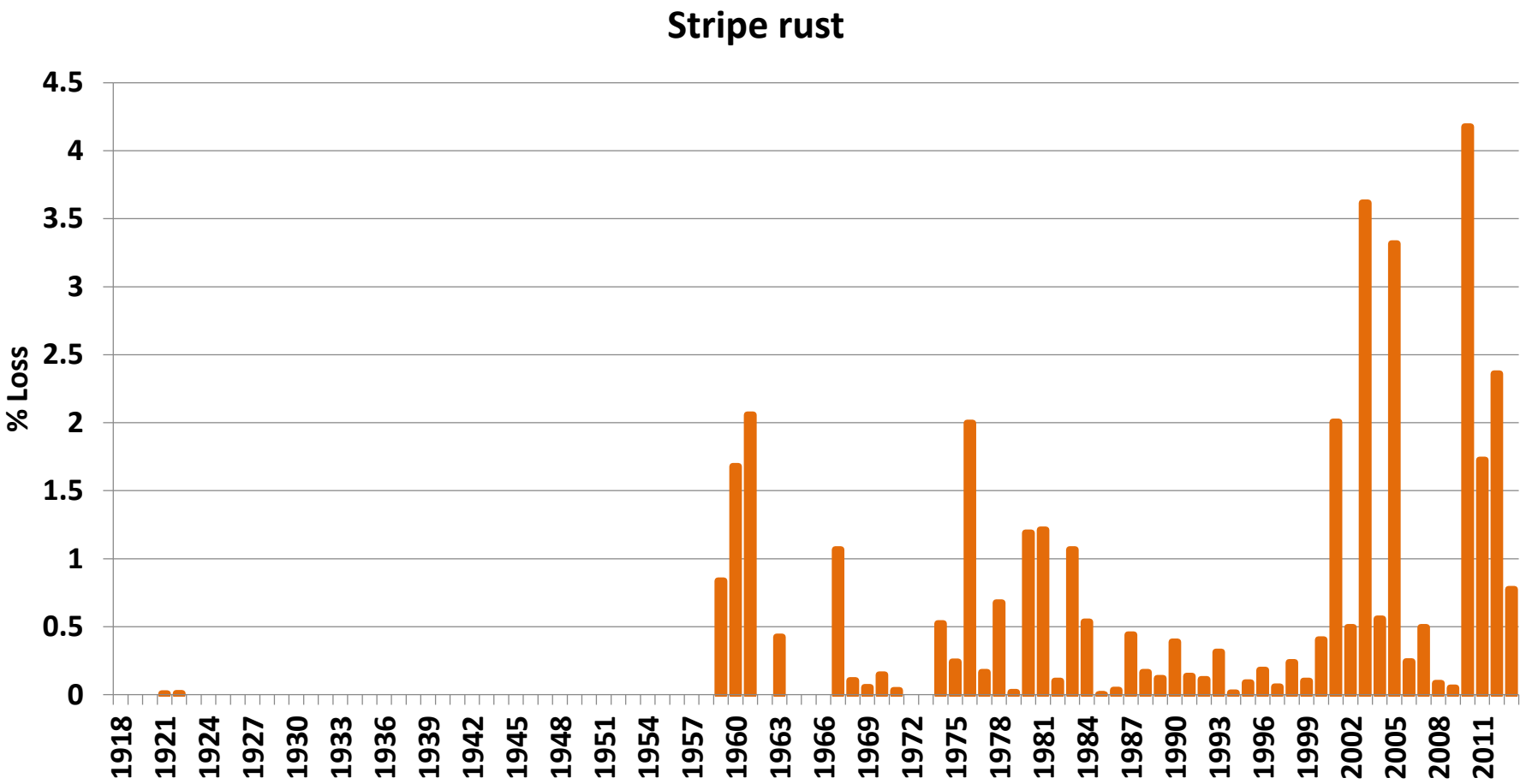
Stem Rust:
Global Assessment Summary

GLOBAL WHEAT LOSS ESTIMATES ATTRIBUTED TO STEM RUST, 1961–2009

Probability of loss	Total period loss (1961–2009)	Implied average annual losses
Percentage	Million metric tons	
90	≥ 275	≥ 5.6
50	≥ 305	≥ 6.2
20	≥ 326	≥ 6.7
5	≥ 347	≥ 7.1
Single-year pandemic: 104		

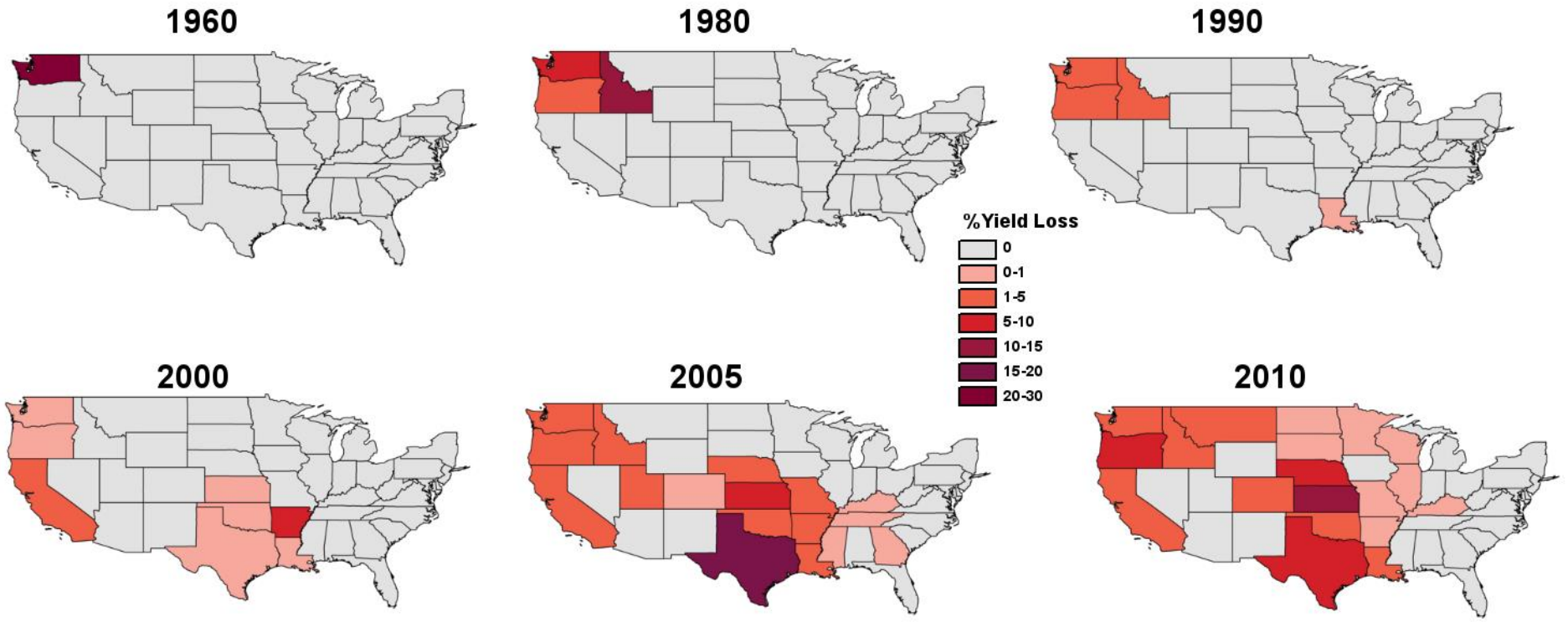
- A sustained investment of $51.1 million per year (2010 prices) in stem rust research could be justified economically

Stripe Rust Losses in the U.S. (by year)



Author's calculation based on USDA CDL data

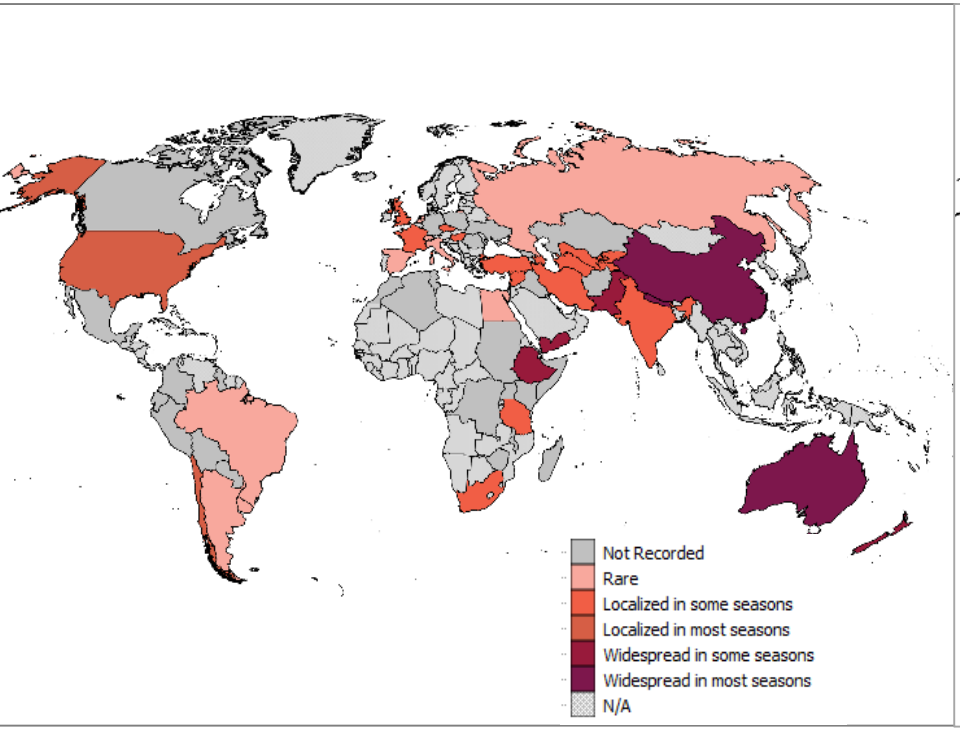
Stripe Rust Losses in the U.S. (by state)

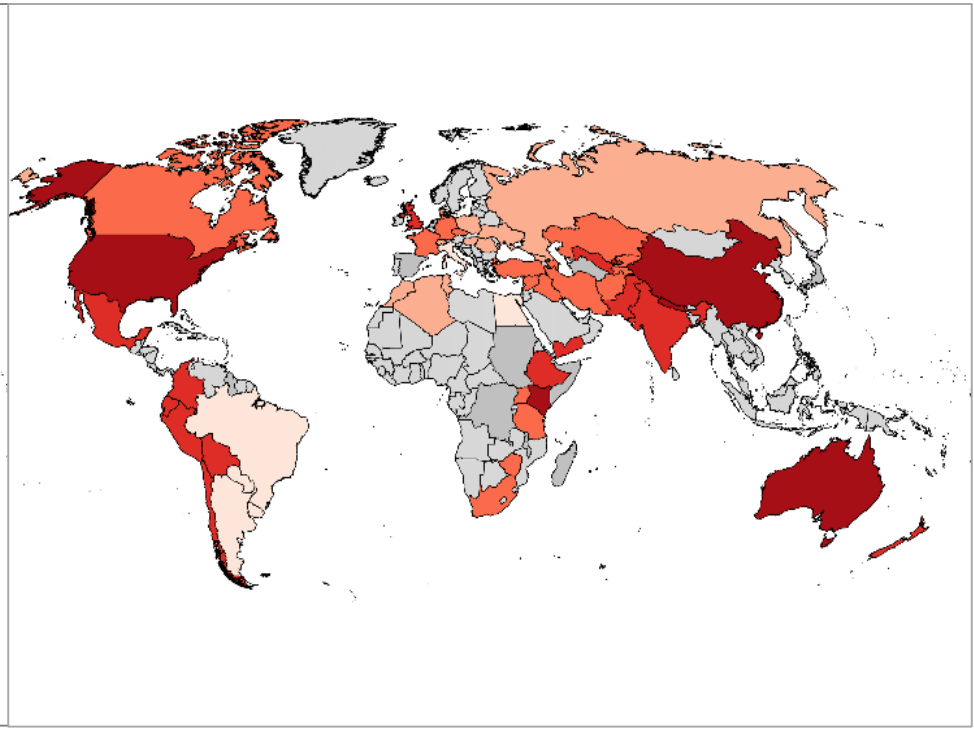


Pre-2000	Mainly the Pacific Northwest (PNW) region
Post-2000	PNW and central states

Author's calculation based on USDA CDL data

Expanding Geography of Stripe Rust





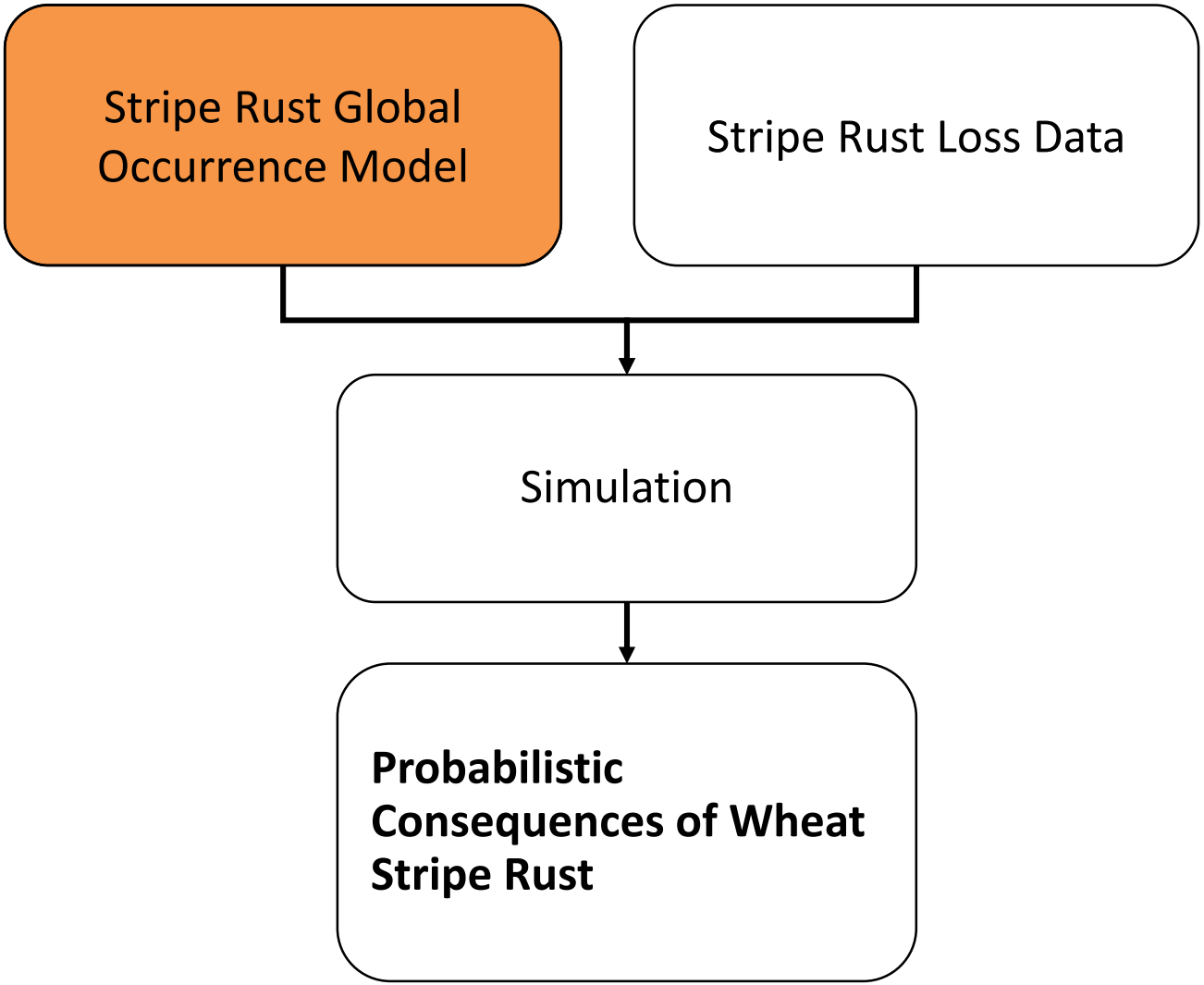
Pre-2000 | **Post-2000**

Data source: 2013 BGRI-HarvestChoice Survey

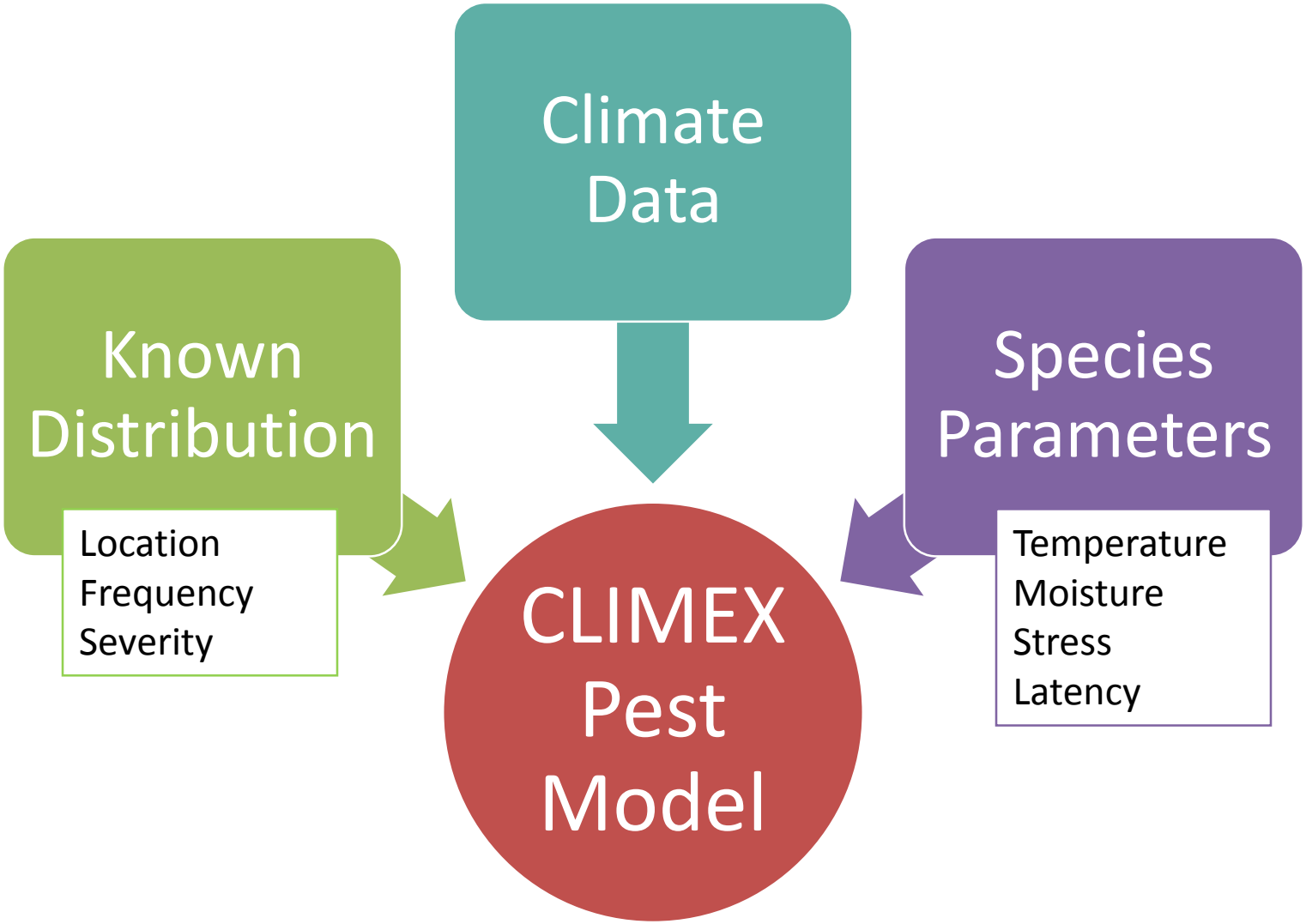
Stripe Rust

- **Expanding Geography**
  - US: epidemics expand from PNW (pre-2000) to Central States (post-2000) (Chen 2005)
  - CWANA: Yr9 and Yr27 driven epidemics since 1980s (Solh et al. 2012)
  - South Africa: first report of stripe rust during 1996 (Pretorius et al. 1997)
  - Australia: annual $40-90 million spent on fungicides (Wellings 2007)
- **Aggressiveness / Increased Fitness**
  - Isolates collected since 2000 are better adapted at warmer temperatures (Milus et al. 2009)
  - Other factors contributed to increased aggressiveness (Loladze et al. 2014)

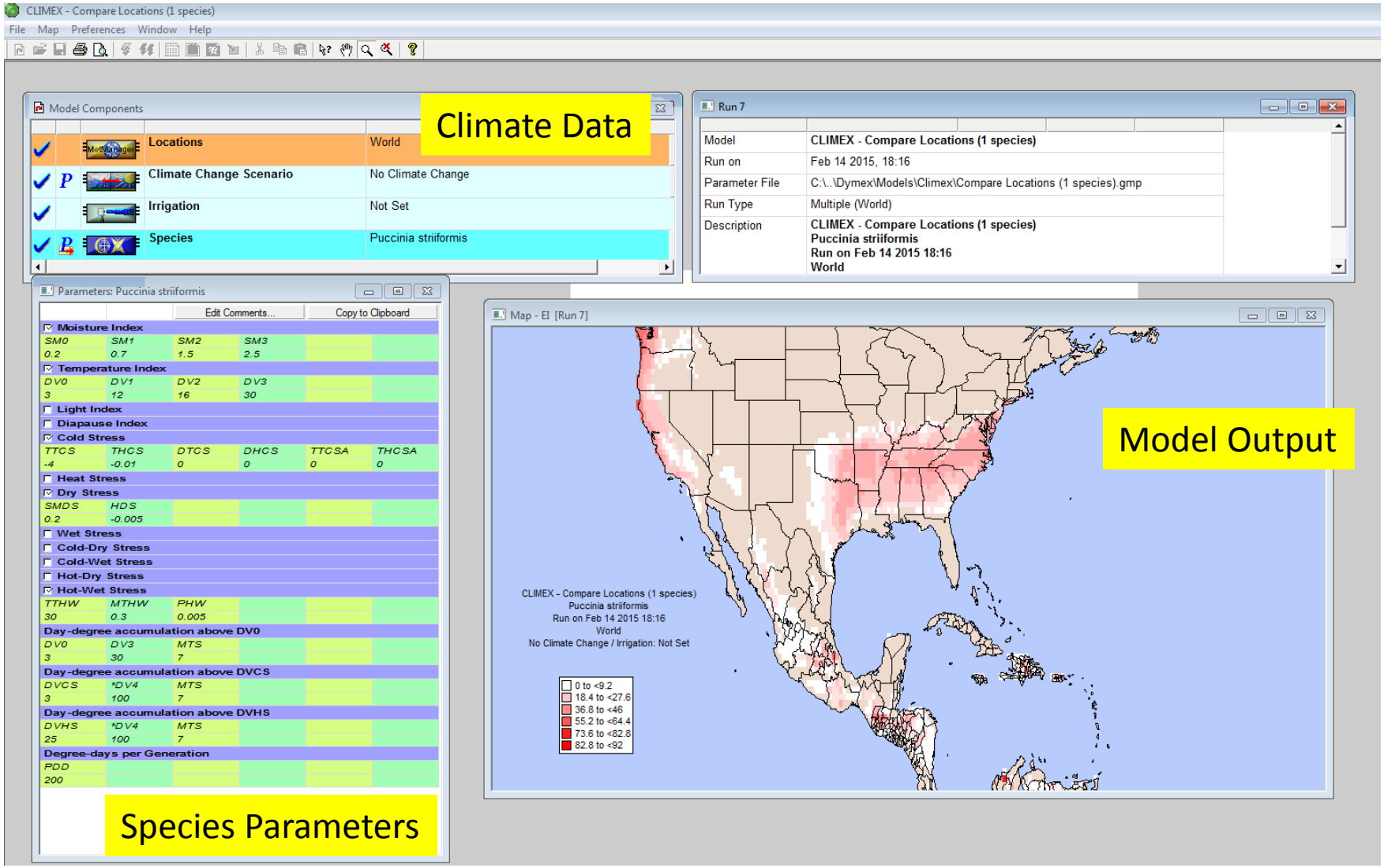
Research Method



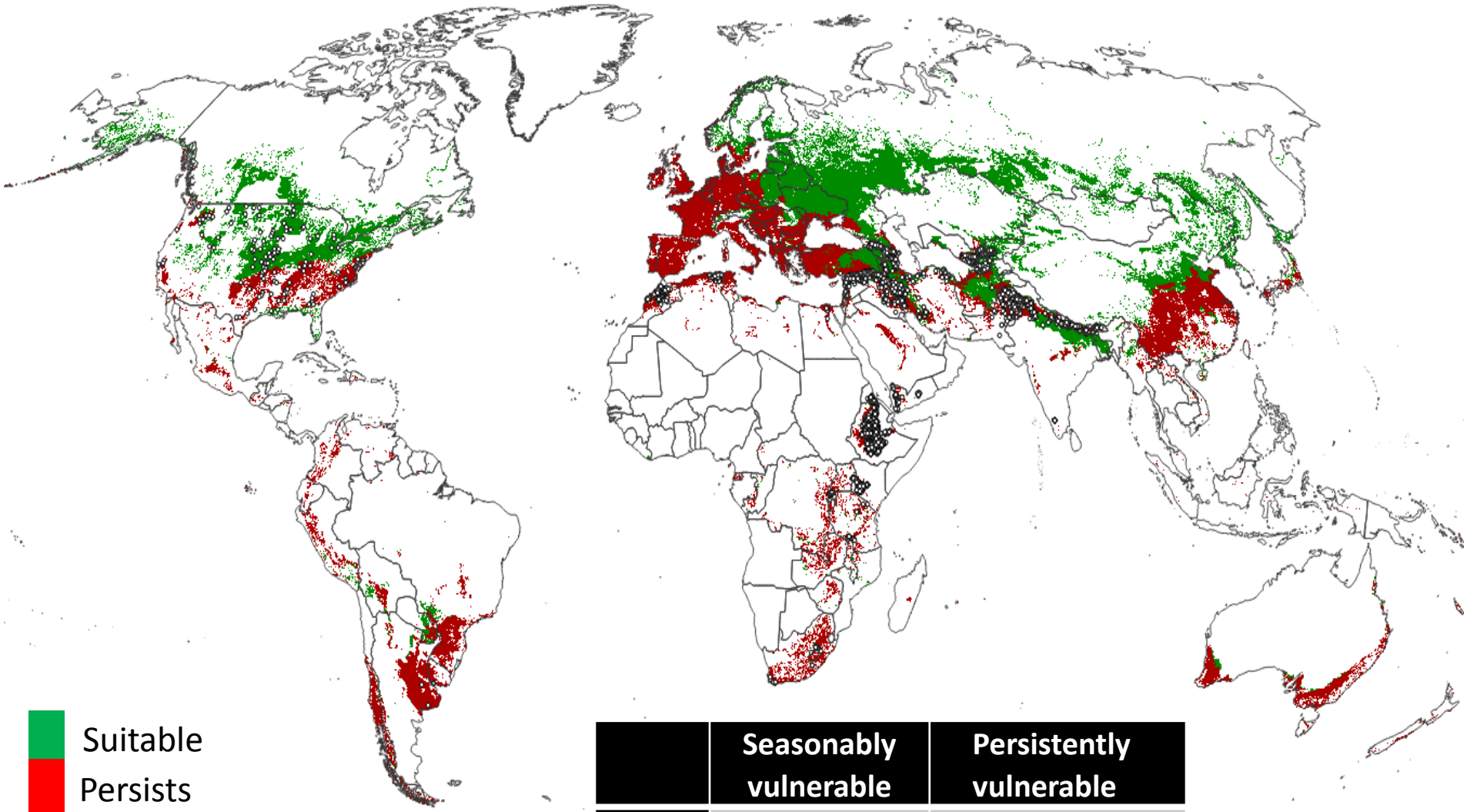
CLIMEX Model of Pests and Diseases



CLIMEX Pest Model



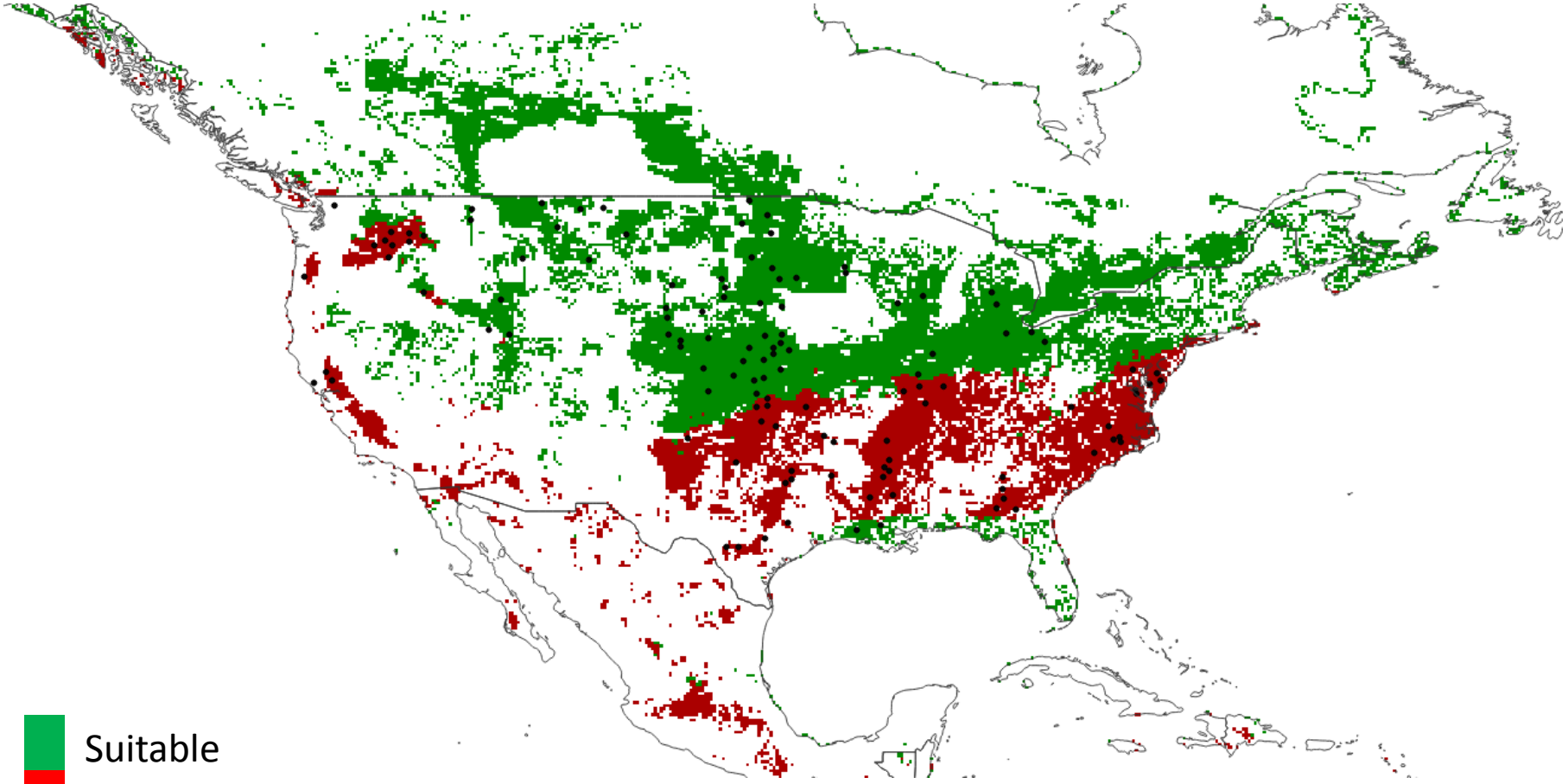
Modeled global climate suitability for stripe rust (Beta)



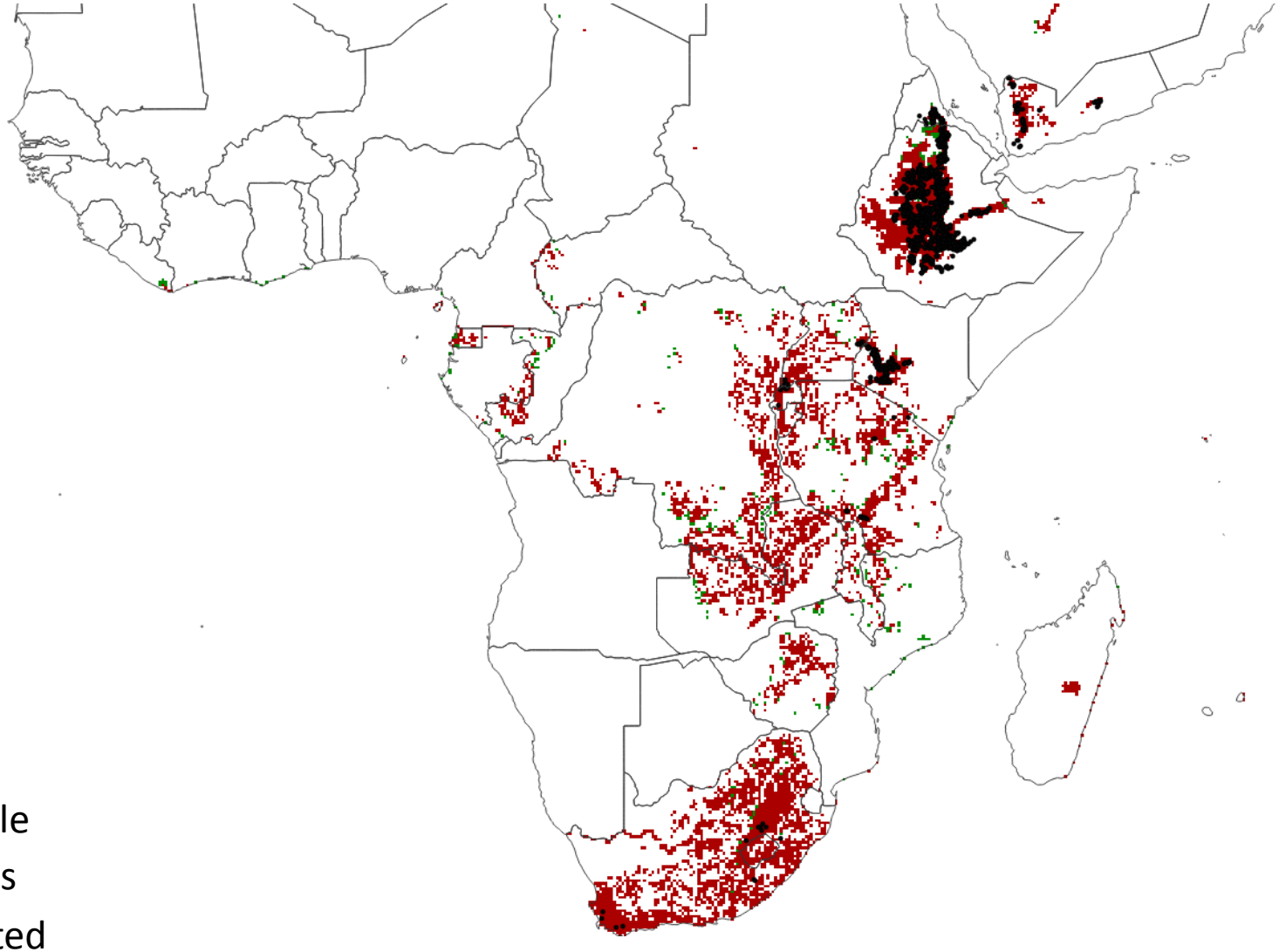
Suitable
Persists
Reported

	Seasonably vulnerable	Persistently vulnerable
World	89.5	56.7

North America (Beta)

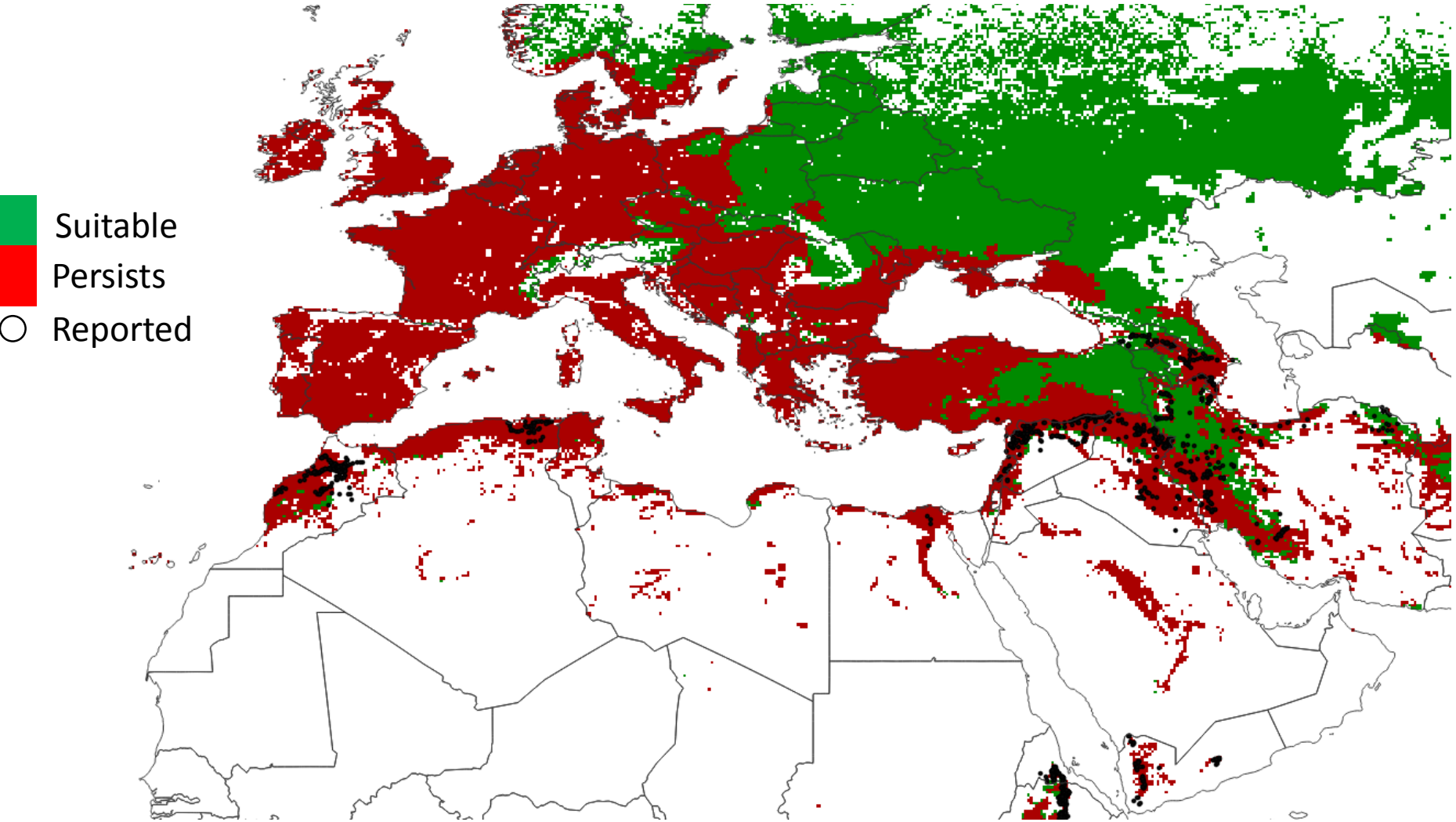


Sub-Saharan Africa (Beta)

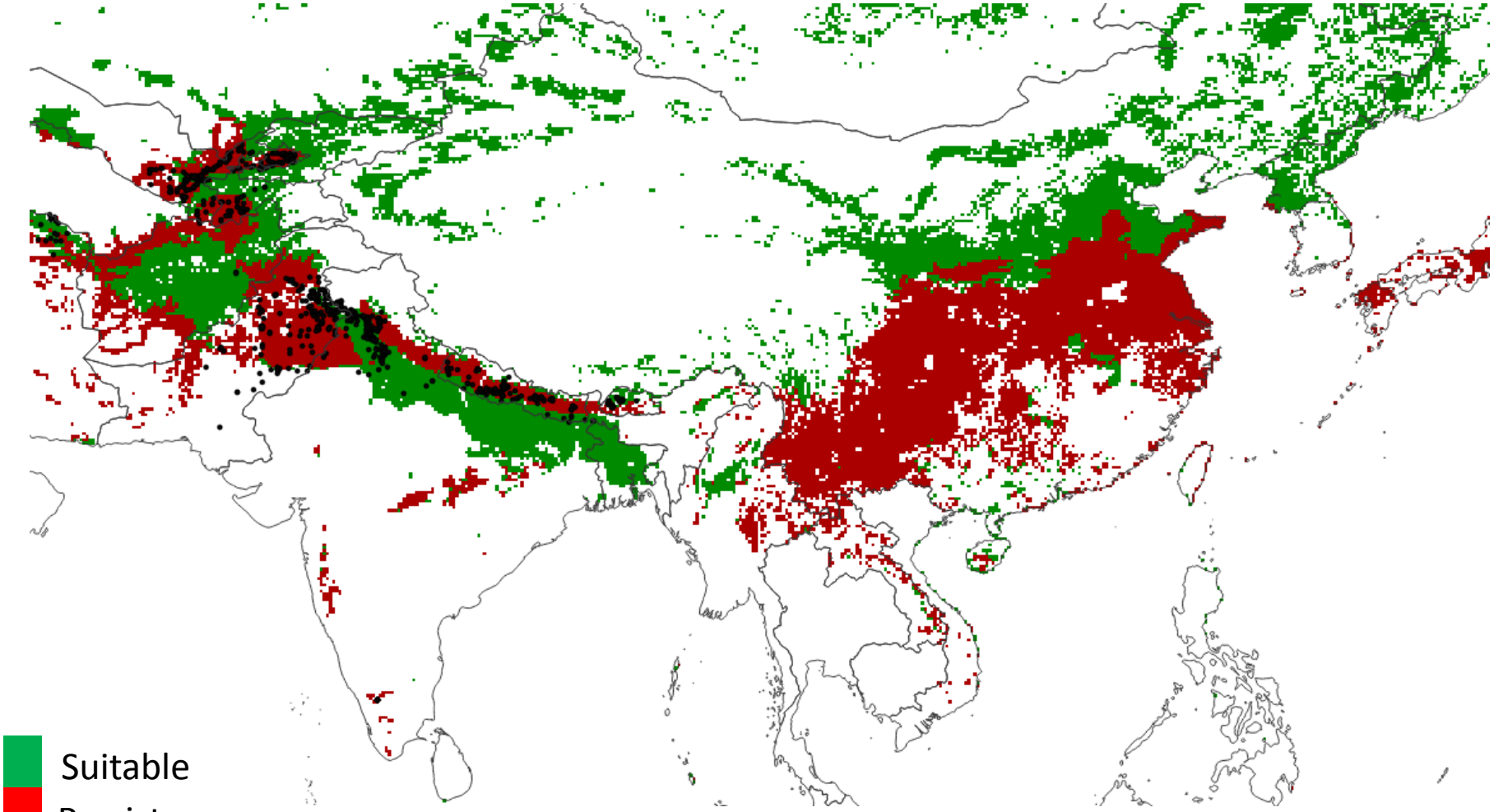


Suitable
Persists
Reported

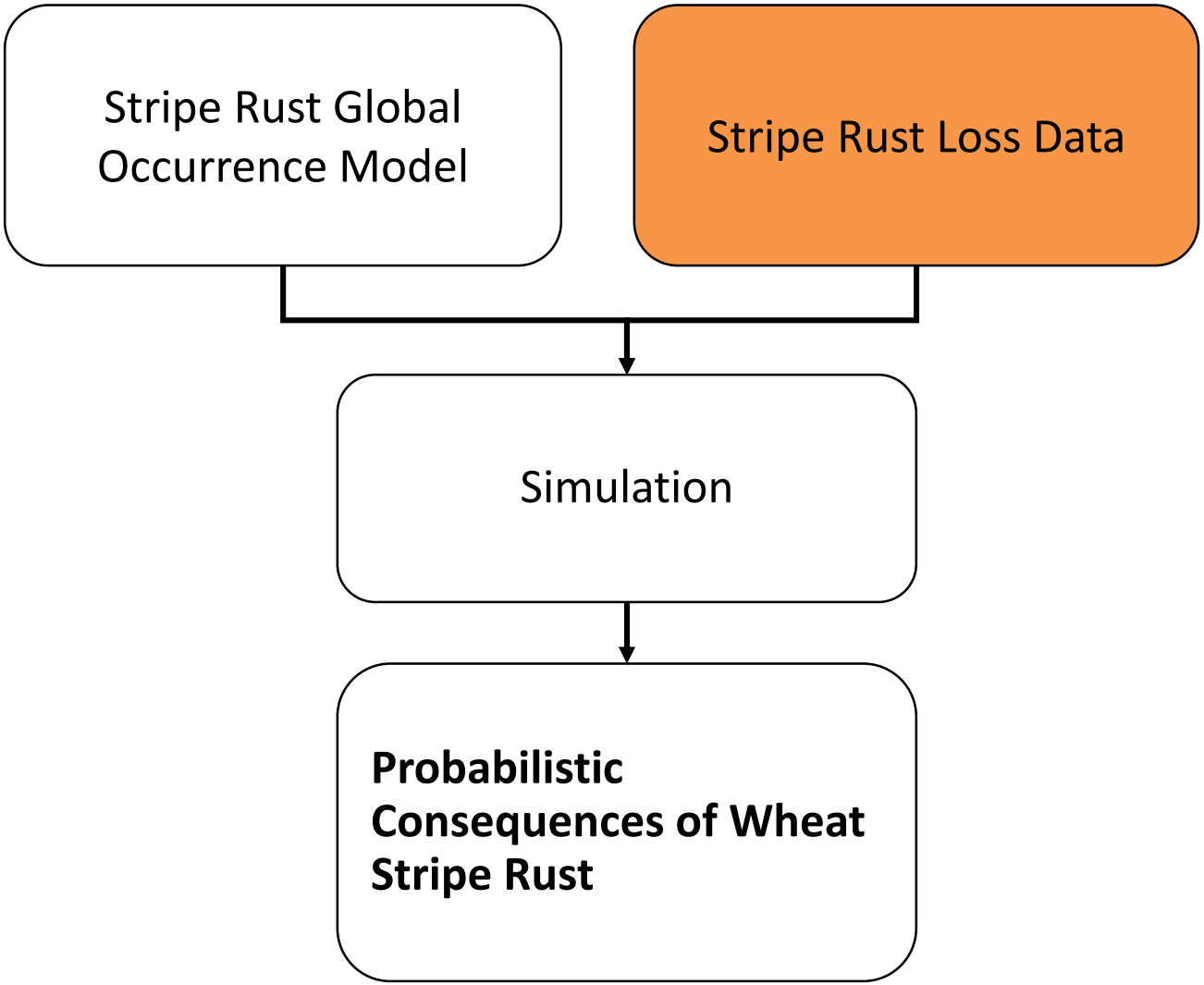
Europe, North Africa and the Middle East (Beta)



Asia (Beta)

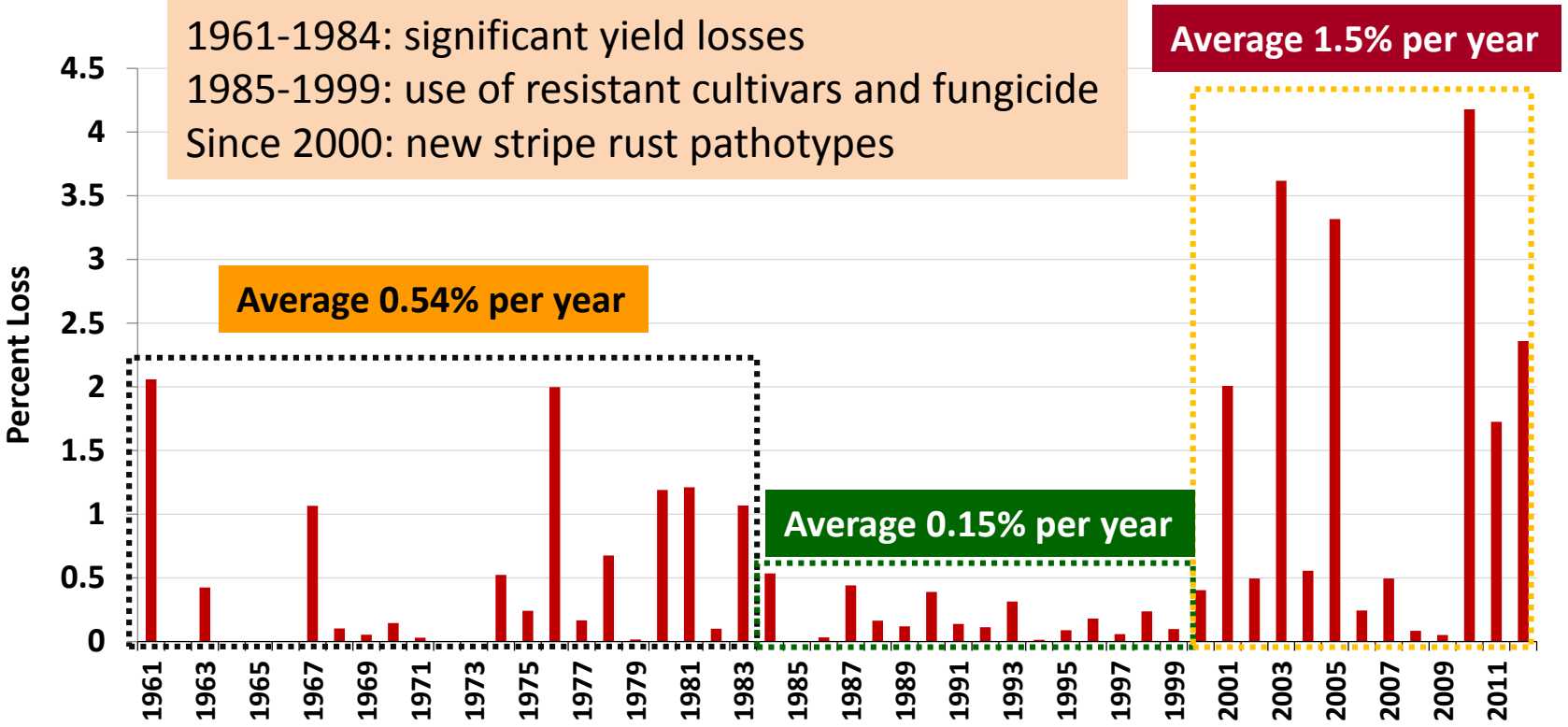


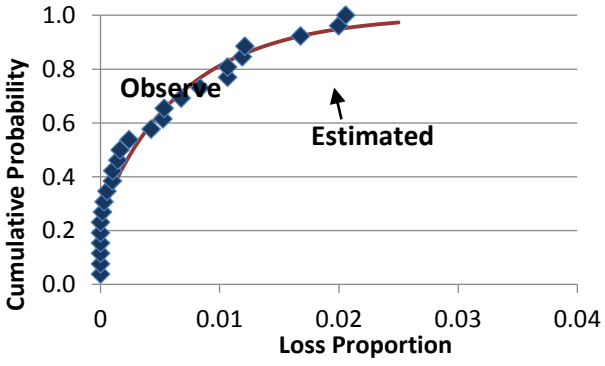
Research Method

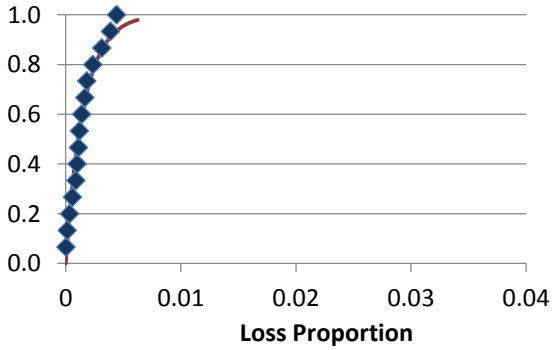


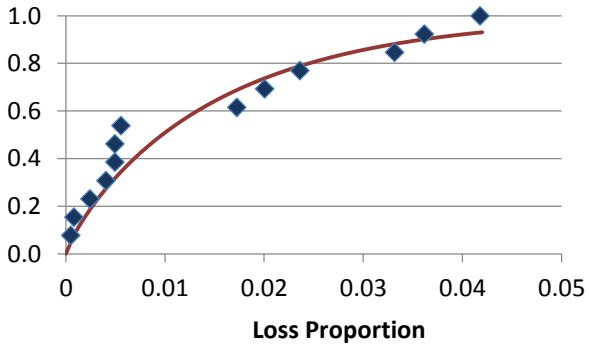
Stochastic Structure of U.S. Losses Attributed to Stripe Rust

1961-1984: significant yield losses
1985-1999: use of resistant cultivars and fungicide
Since 2000: new stripe rust pathotypes

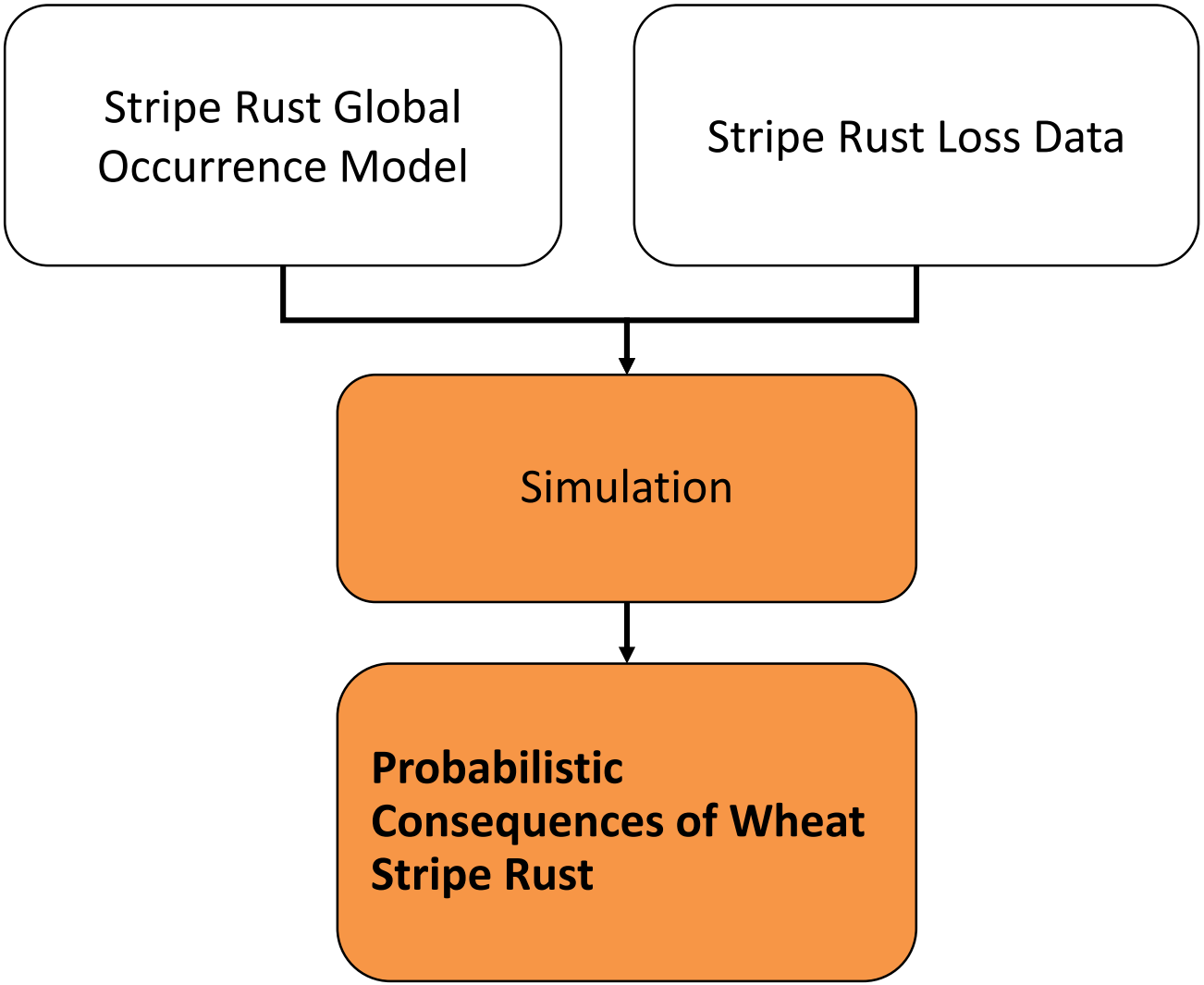




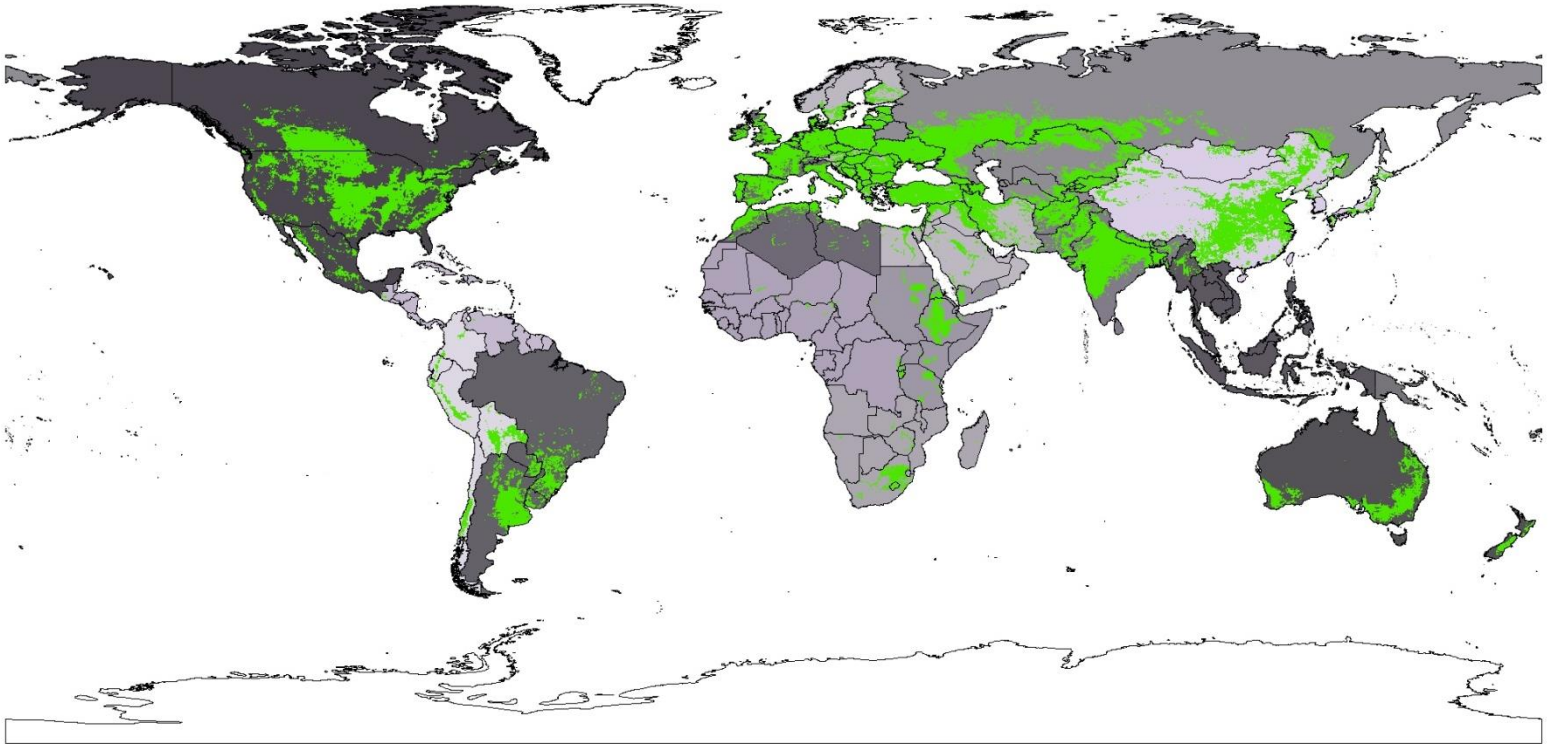




Research Method

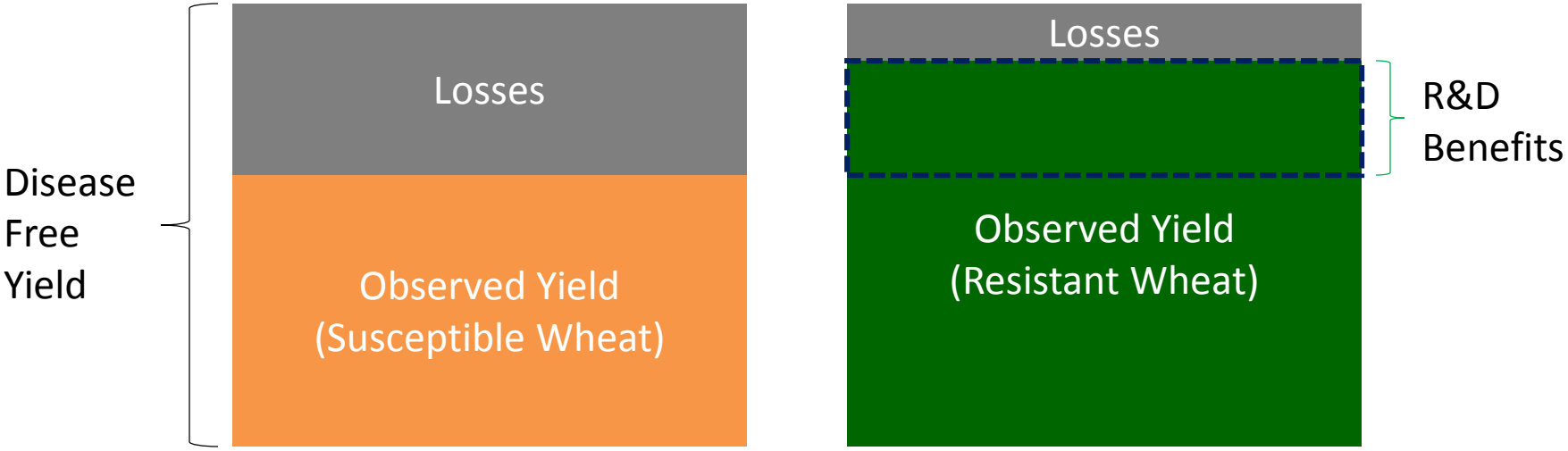


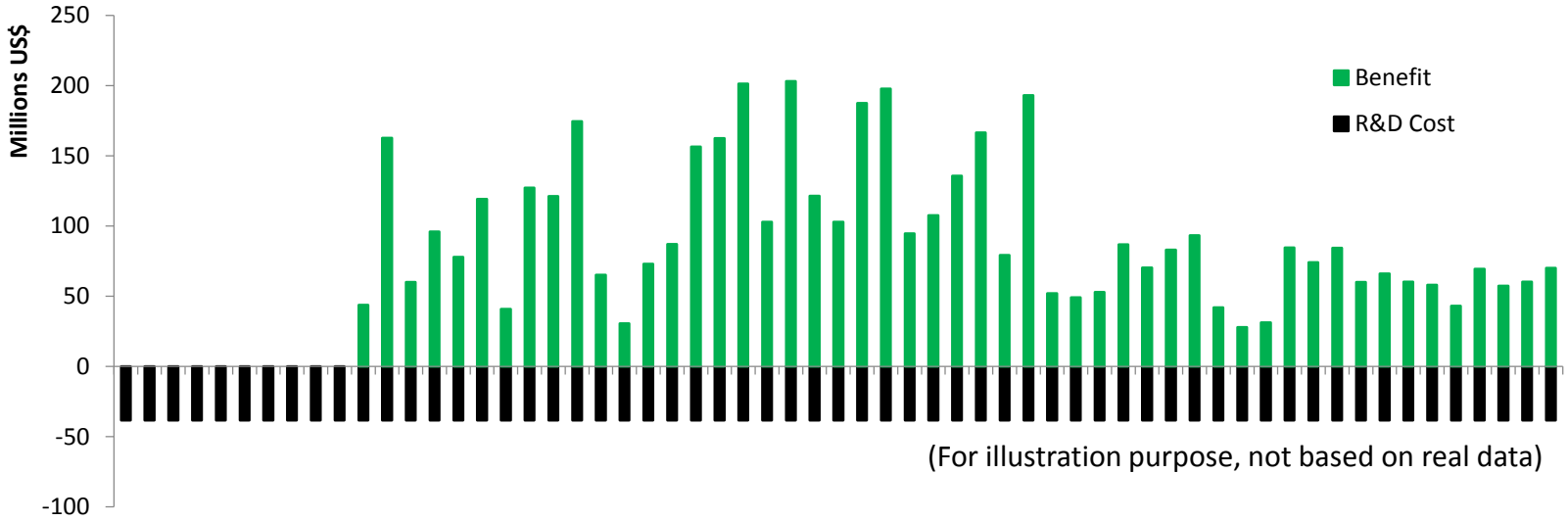
15 Epidemiological Zones



- Following Saari and Prescott (1985), 15 Epidemiological Zones
  - Epidemic in each epidemiological zone occurs independently
- HavestChoices Spatial Allocation Model (SpAM)
  - 10 arc minute resolution: Output / Area / Yield

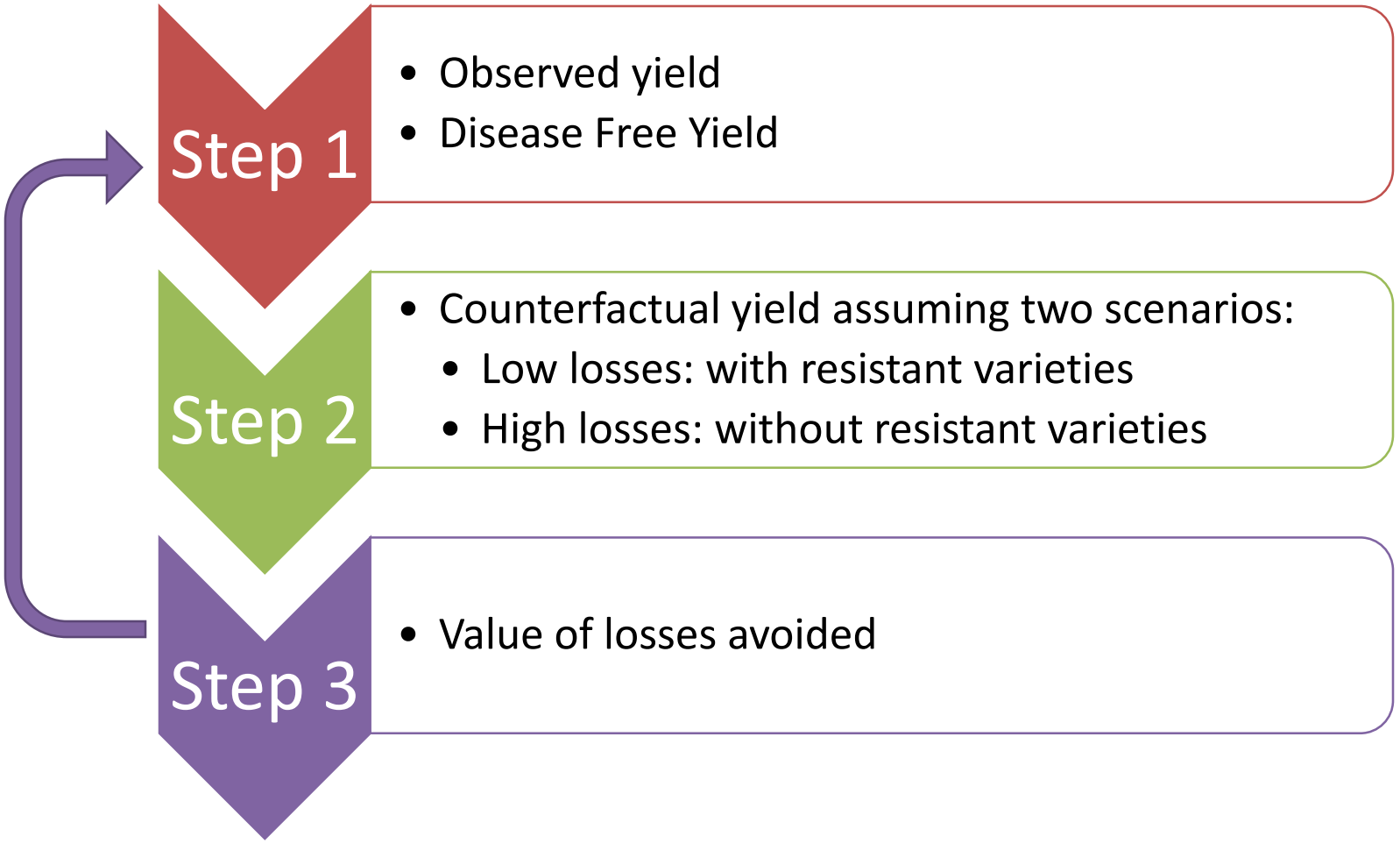
Estimate R&D benefits





$$\text{Present Value of Cost} \times (1 + 10\%)^{\text{T}} = \text{Future Value of Benefits}$$

Monte Carlo Simulation



Probabilistic Losses Attributable to Stripe Rust

Probability of Loss	Limited Area Extent (1961-1984)		Extended Area Extent (2000-2012)	
	Volume	Value	Volume	Value
(percentage)	(million tonnes)	(million $US)	(million tonnes)	(million $US)
90	≥ 0.65	≥ 172	≥ 4.40	≥ 1,170
50	≥ 0.79	≥ 209	≥ 5.22	≥ 1,389
20	≥ 0.88	≥ 235	≥ 5.82	≥ 1,549
5	≥ 0.98	≥ 262	≥ 6.42	≥ 1,718
Mean	≥ 0.79	≥ 210	≥ 5.25	≥ 1,398

Preliminary Data. Do Not Quote

*Benchmarked relative to 1985-1999 U.S. losses

Research Investments Attributable to Rust

Economic justification:
Developing effective resistance through R&D investment is more beneficial than exposing susceptible wheat to rust epidemics

Reference Period	Stripe Rust	Stem Rust
2000-2050	(2010 prices)	
Annual Spending (Economically Justifiable)**	$38.6 million	$51.1 million
Per Hectare*	(18 cents)	(23 cents)

Preliminary Data: Do Not Quote

*In comparison, U.S. wheat farmers spent $27.69 per hectare on seed in 2010

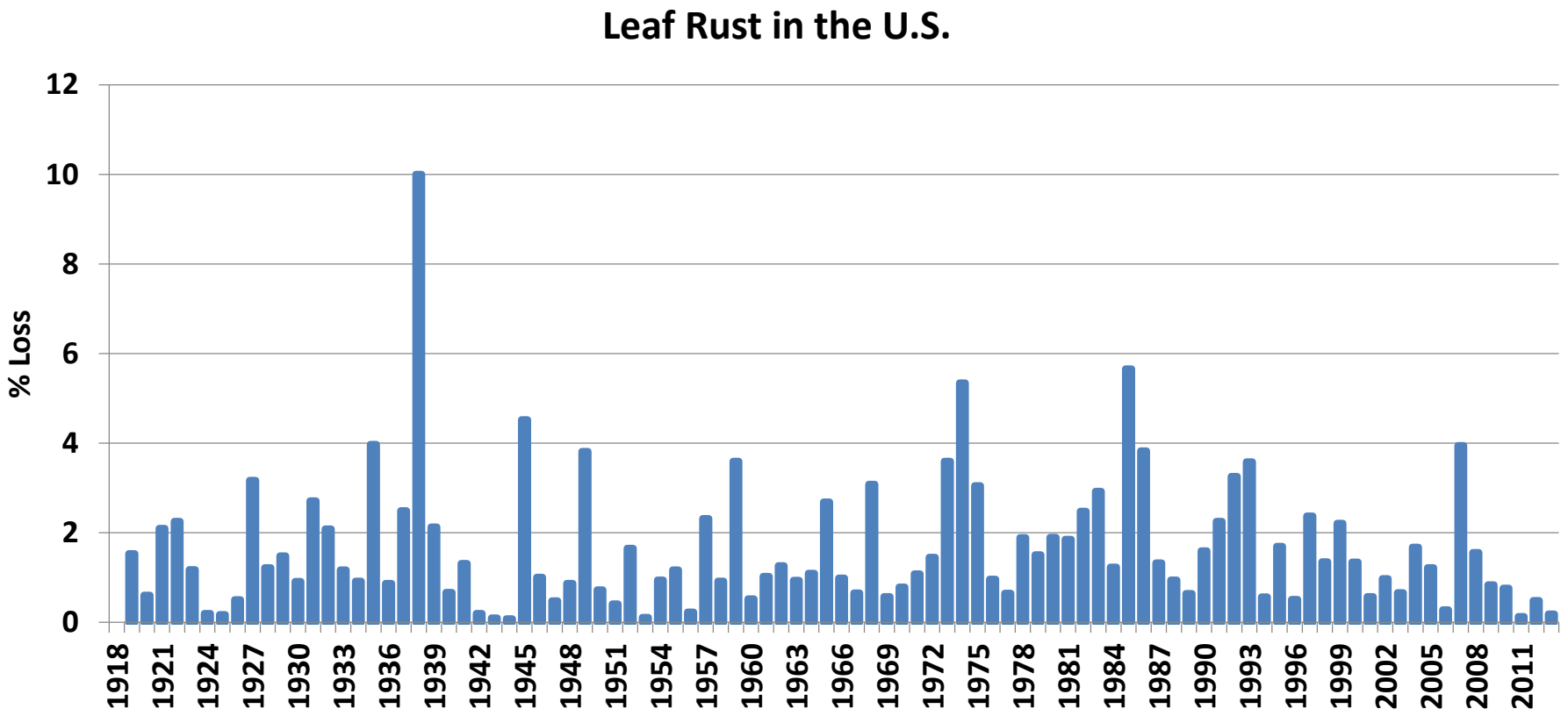
**Actual stem rust R&D spending is estimated less than half the amount, and stripe rust spending is even less than stem rust

Summary

- Rapid spread of stripe rust epidemics
  - Spatial expansion: almost 90 percent of the world's wheat production is susceptible to stripe rust
  - Frequency increase
  - Losses severe

- Our (beta) assessment suggests that around $39 million per year be spent to alleviate global losses from stripe rust
  - About three quarters the corresponding stem rust research investment
  - Difference
    - Stem Rust: projected losses
    - Stripe Rust: observed losses

Future Work: Leaf Rust



Author's calculation based on USDA CDL data

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