CLIMATE CHANGE IMPACTS ON THE INVASIVE BROWN MARMORATED STINK BUG

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Brown marmorated stink bug (BMSB)
Halyomorpha halys

- **Native to Eastern Asia (China, Japan and Korea)**
- **Over 300 host plants including applies, peaches, sweet corn, tomatoes, soybean, and ornamental trees**
- **Invaded vast areas of North America (1996) and Europe (2004)**
- **Severe tree fruit pest in Mid-Atlantic USA and Northern Italy**
- **Recently confirmed in Chile (2017)**

Climate Change and *H. halys*

DIRECT IMPACTS

- Geographic Range Shifts/Expansions (Northward)
- Voltinism (↑ number of generations per year)
- Winter Survival (chill intolerant species)
- Length of Growing Season (Earlier spring emergence in Japan)

MANAGEMENT IMPACTS

- Increase pest risks in novel or established regions
- Timing of Insecticide Applications
- Host Plant-Pest Synchrony

Study Objectives

- **Examine how climate change may affect *H. halys*'**

  1) **Potential global distribution**

  2) **Seasonal phenology (weekly Growth Index, GIw)**

  3) **Number of generations per year (GDD)**

- **Inform current and future management of *H. halys* in light of climate change**

Modelling Species Distribution & Abundance Using CLIMEX

- **Process-oriented modelling**

- **Describes how a species responds to the environment**

- **Based on eco-physiological growth model**
  - **Growing Degree Days requirements**
  - **Diapause requirements (for overwintering insects)**
  - **Min and Max Temperature & Moisture Thresholds (Stress Indices)**

- **Inference of geographical and seasonal climatic suitability, length of growing season, number of generations**

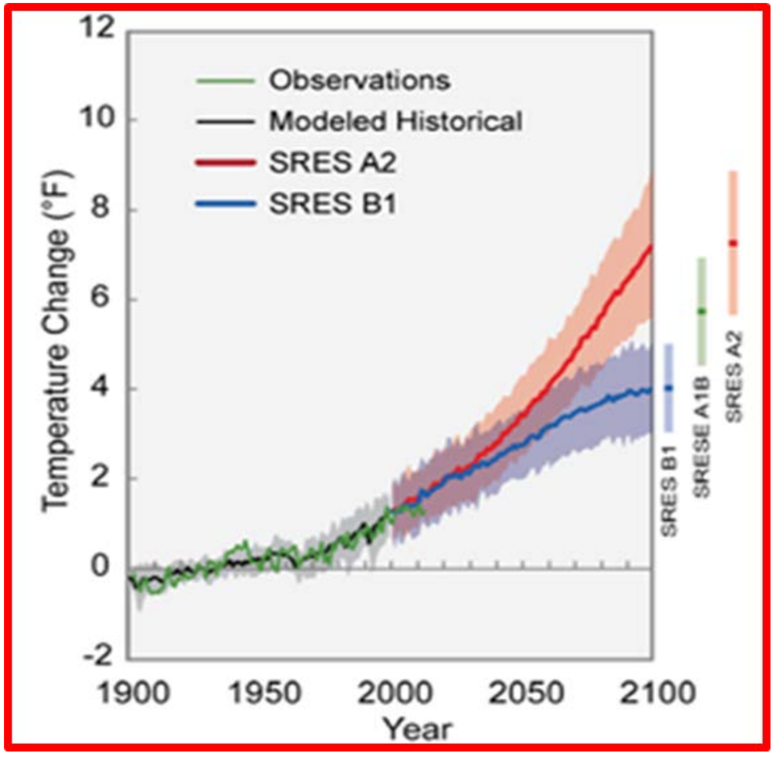
CLIMEX Parameter Values for *Halyomorpha halys*

Index	Parameter	Values
Temperature	DV0 = Limiting low average weekly temperature	12ºC
	DV1 = Lower optimal average weekly minimum temperature	27ºC
	DV2 = Upper optimal average weekly maximum temperature	30ºC
	DV3 = Limiting high average weekly temperature	33ºC
Degree-days	PDD = Minimum degrees days above 12ºC (DV0) to complete a single generation	595ºC days
Moisture	SM0 = Lower soil moisture threshold	0.1
	SM1 = Lower optimal soil moisture	0.5
	SM2 = Upper optimal soil moisture	1
	SM3 = Upper soil moisture threshold	1.5
Cold Stress	TTCS = Cold stress threshold (average minimum weekly temperature)	-18ºC
	TTCS = Rate of cold stress accumulation	-0.01 $Week^{-1}$
Heat Stress	TTCS = Heat stress threshold (average maximum weekly temperature)	33ºC
	TTCS = Rate of heat stress accumulation	0.01 $Week^{-1}$
Dry Stress	SMDS = Dry stress threshold (average weekly minimum soil moisture)	0.1
	HDS = Rate of dry stress accumulation	-0.01 $Week^{-1}$
Wet Stress	SMDS = Wet stress threshold (average weekly maximum soil moisture)	1.5
	HWS = Rate of wet stress accumulation	0.002 $Week^{-1}$
Diapause Index	DPD0 = Diapause induction day length	12 h light
	DPT0 = Diapause induction temperature (average weekly minimum)	5
	DPT1 = Diapause termination temperature (average weekly minimum)	5
	DPD = Diapause development days	0
	DPSW = summer/winter switch	0 (winter)
Heat-Wet Stress	TTHW = Hot-Wet temperature threshold (average maximum weekly temperature)	28
	MTHW = Hot-Wet moisture threshold (average weekly maximum soil moisture)	1.5
	PHW= Rate of heat-wet stress accumulation	0.007

Model parameters were adopted from **Kriticos et al. (2017).** Values without units are dimensionless indices of plant available soil moisture.

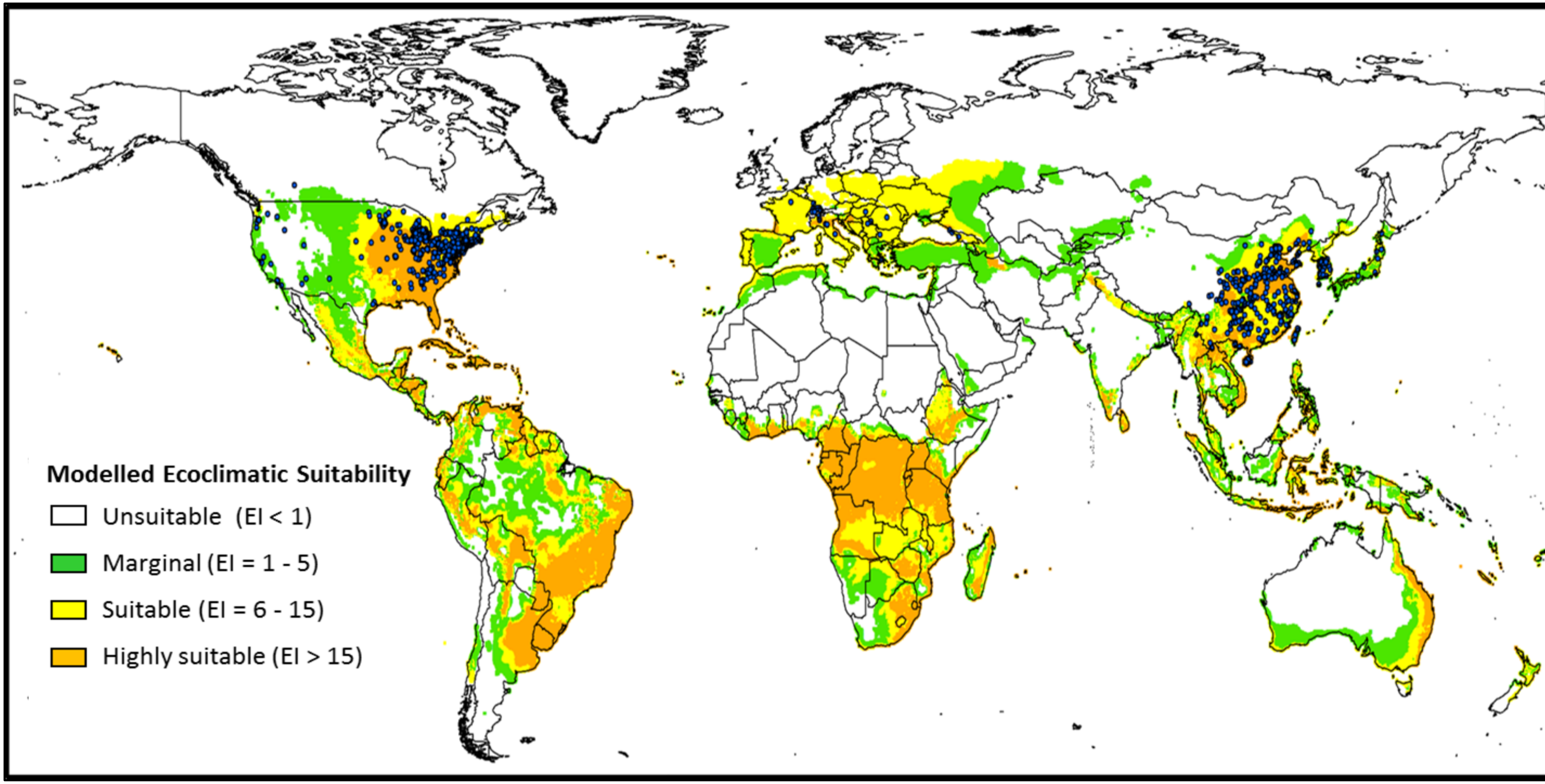
Future Climate Projections (CliMond)

- **Baseline: Recent historical climate (1951-2000)**
- **SRES A2 Emission Scenario (High Emission, Business as usual)**
- **2 General Circulation Models (GCMs)**
  - **CSIRO-Mk3.0 (↑ 2.11°C by 2100)**
  - **MIROC-H (↑ 4.31°C by 2100), article only**
- **Projections for 2050 and 2100**



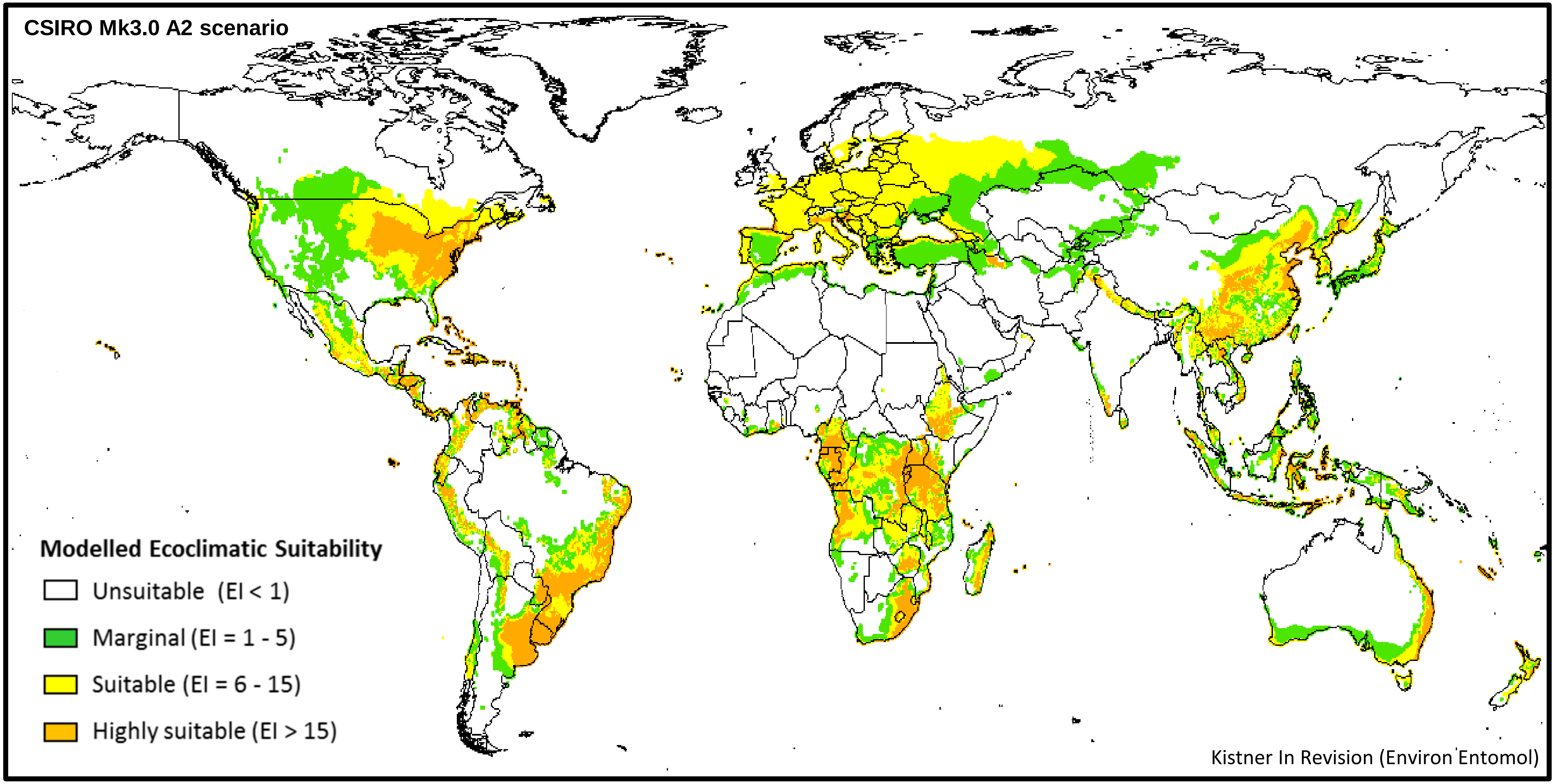
Modelled Global Climatic Suitability for *H. halys*

Recent Historical Climate

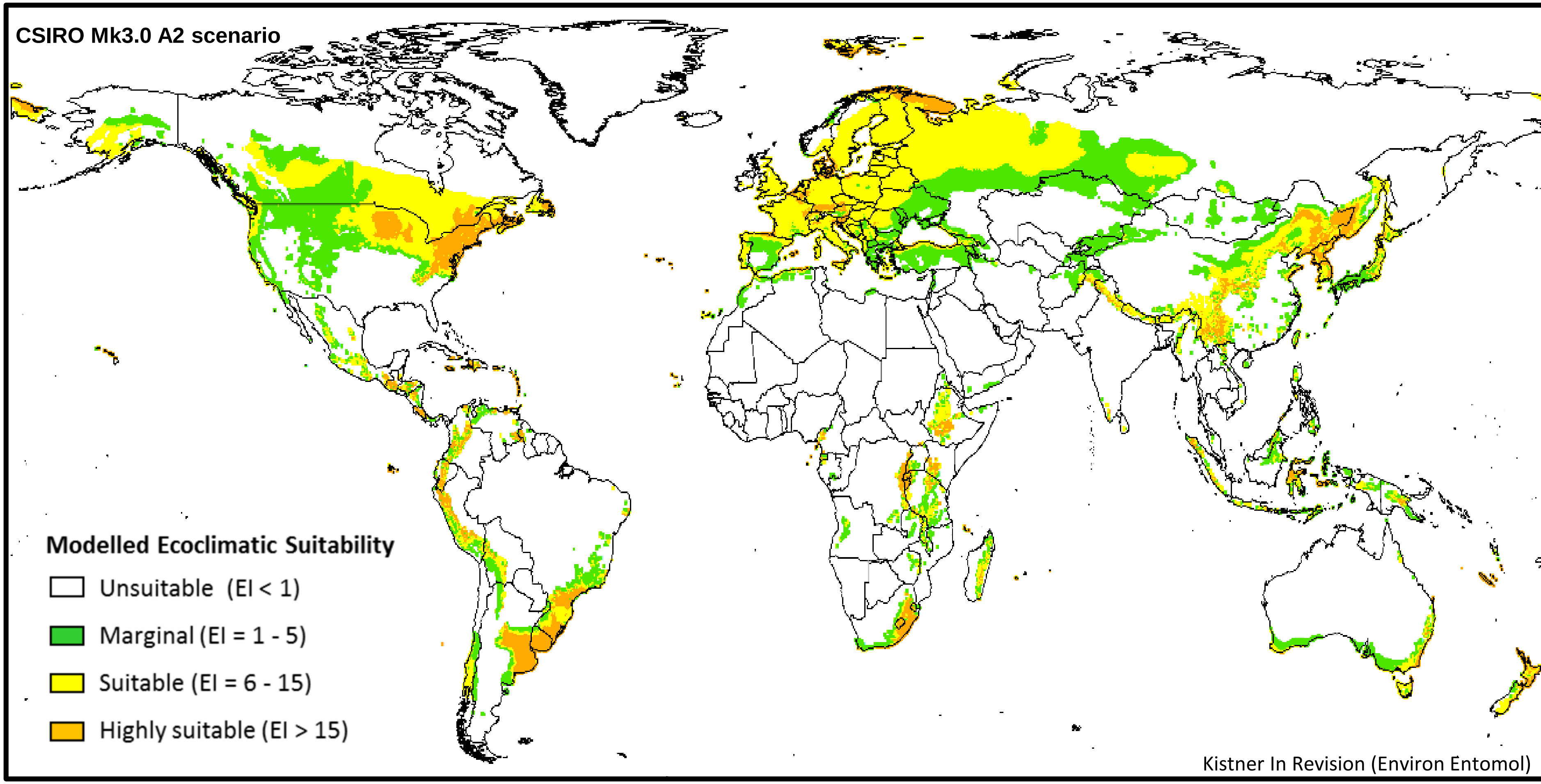


- **<u>Model Validation:</u> Predicted distribution has 99.6 % match with known distribution**
- **Potential exists for further establishment and spread (See Kriticos et al. 2017)**

2050 Global Modelled Climatic Suitability for *H. halys*



2100 Global Modelled Climatic Suitability for *H. halys*

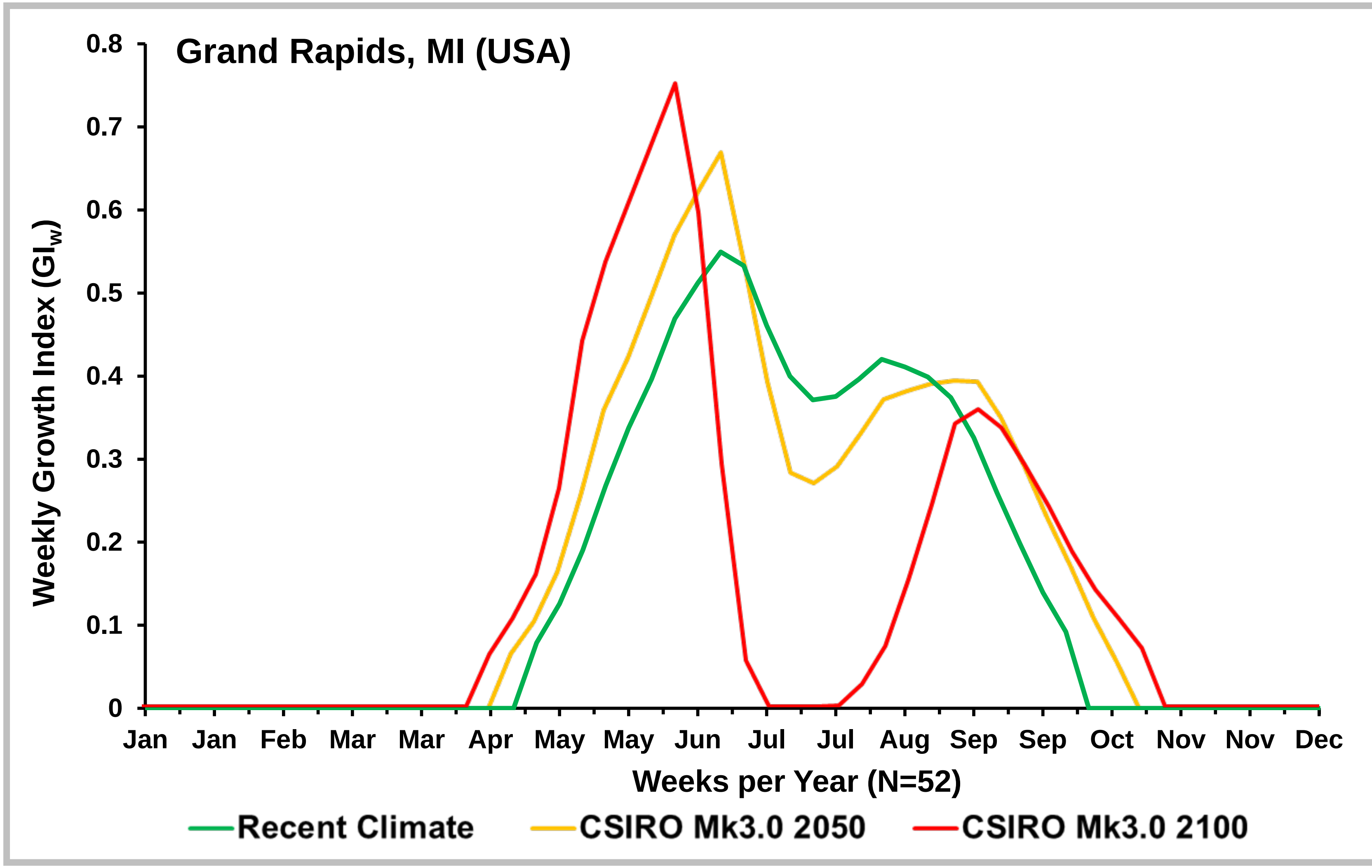


CLIMEX Projected Number of *H. halys* Generations

Location	Observed	Recent Historical	CSIRO 2050	CSIRO 2100
USA				
Allentown, Pennsylvania	1	2.08	2.55	3.39
Asheville, North Carolina	2	2.38	2.96	4.00
Grand Rapids, Michigan	1	1.73	2.26	3.27
Portland, Oregon	1 to 1.5?	1.52	1.96	2.78
Europe				
Zurich, Switzerland	1	1.02	1.38	2.04
Modena, Italy	2	2.51	3.06	4.01
Canada				
Montreal, Quebec	?	1.43	1.38	2.04
Niagara-Fonthill, Ontario	?	1.57	2.09	3.06
China				
Mentougou, Beijing	1	1.86	2.42	3.46
Pingxiang, Guangxi	4-6	6.20	7.38	9.10

Based on 595^{o}C degree day threshold above 12^{o}C.

Changes in *H. halys* Growing Season



- Growing season extended by 3 weeks by 2050 and 6 weeks by 2100, respectively
- Reduced summer growth potential due to increased temperatures

Conclusions and Limitations

- Range shifts northward and contracts in the southern latitudes
- Canada and Europe are especially at risk under future climate change
- Multiple generations are likely under future warming
- Changes in the growing season will affect the timing and frequency of insecticide applications
- CLIMEX assumes only climate affects a species distribution
- Run simulations incorporating crop distribution data

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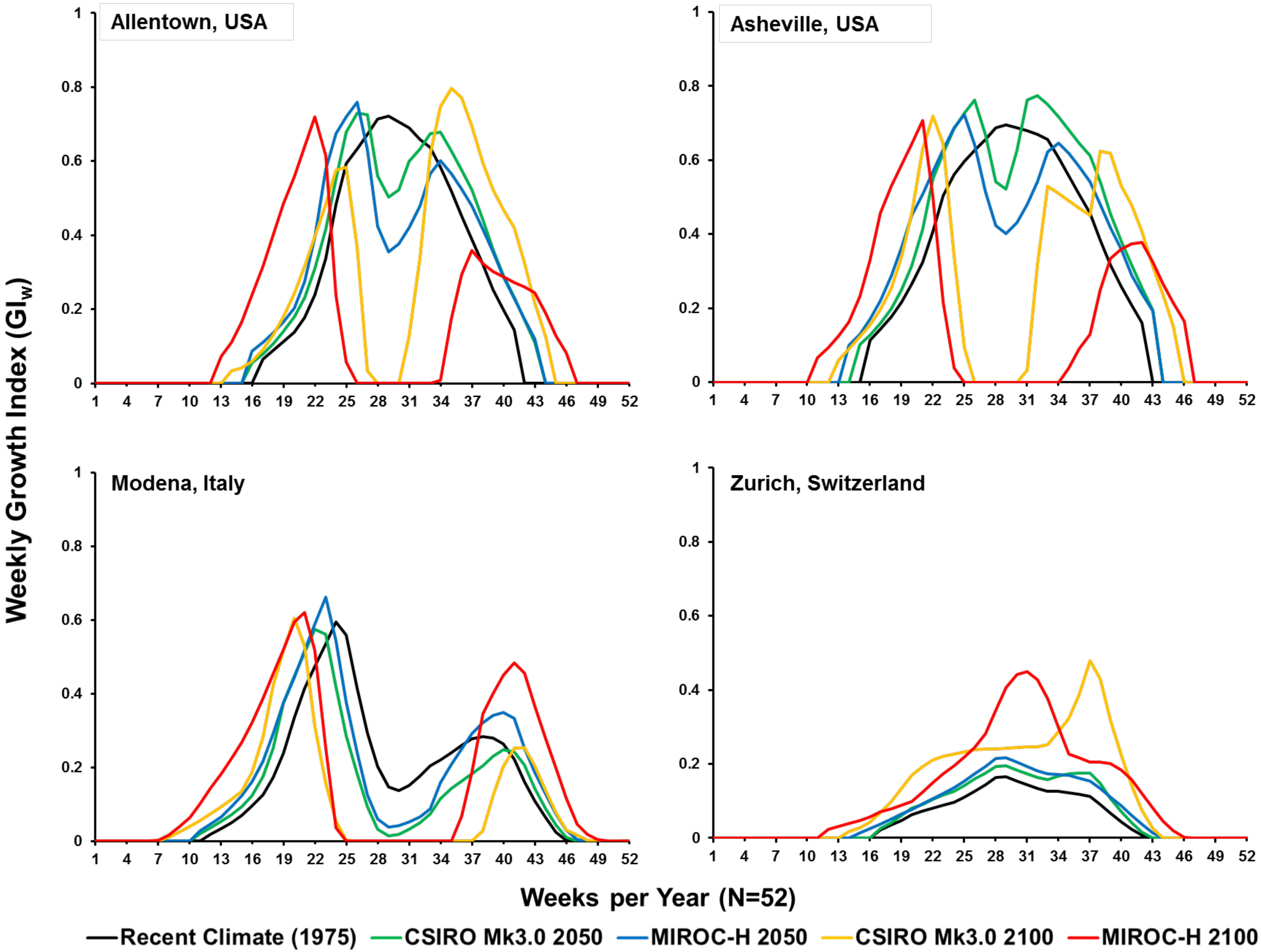
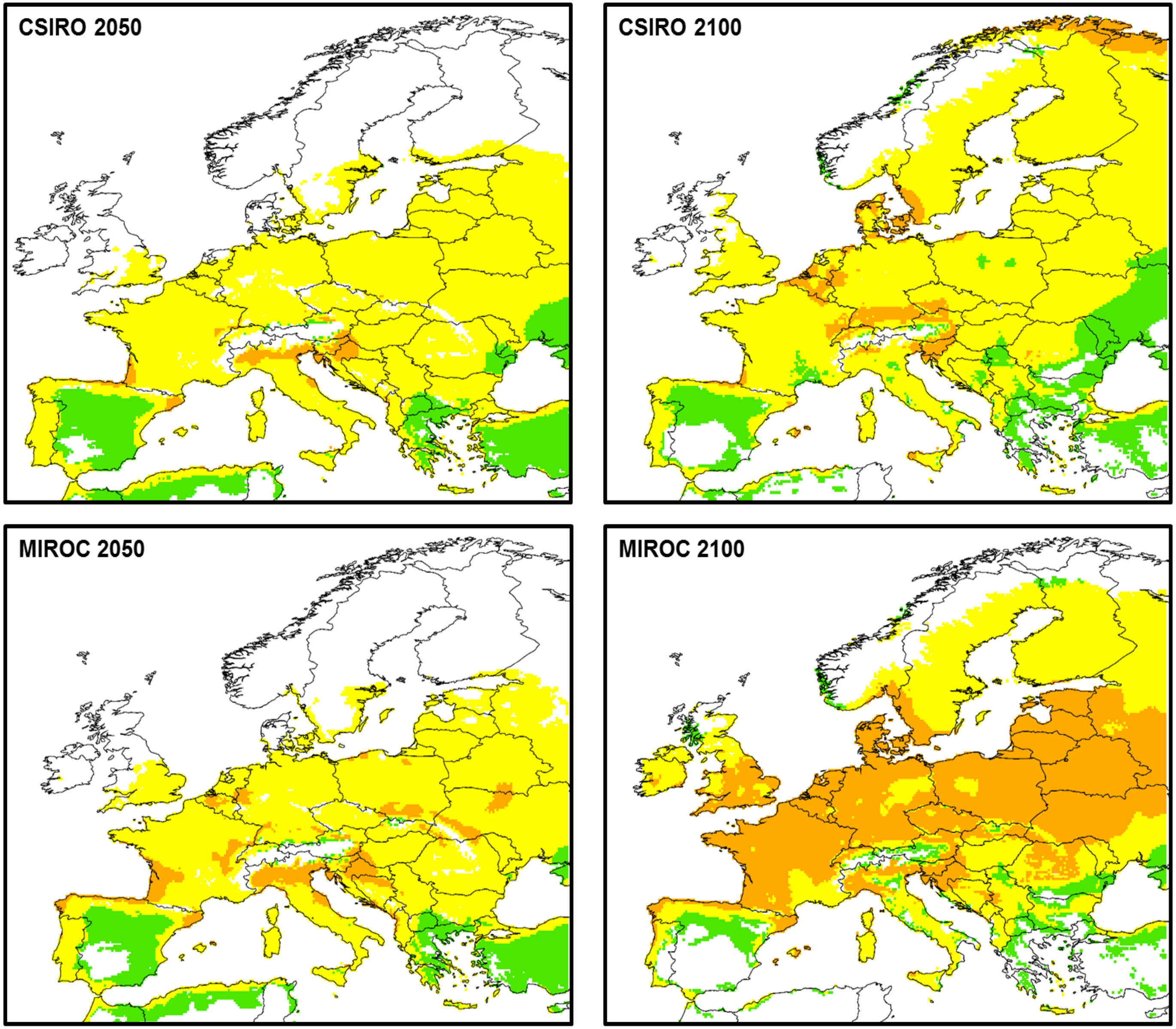

Allentown, USA
Asheville, USA
Modena, Italy
Zurich, Switzerland
Weekly Growth Index (GI_W)
Weeks per Year (N=52)
Recent Climate (1975)
CSIRO Mk3.0 2050
MIROC-H 2050
CSIRO Mk3.0 2100
MIROC-H 2100

Modelled Future Climatic Suitability in Europe

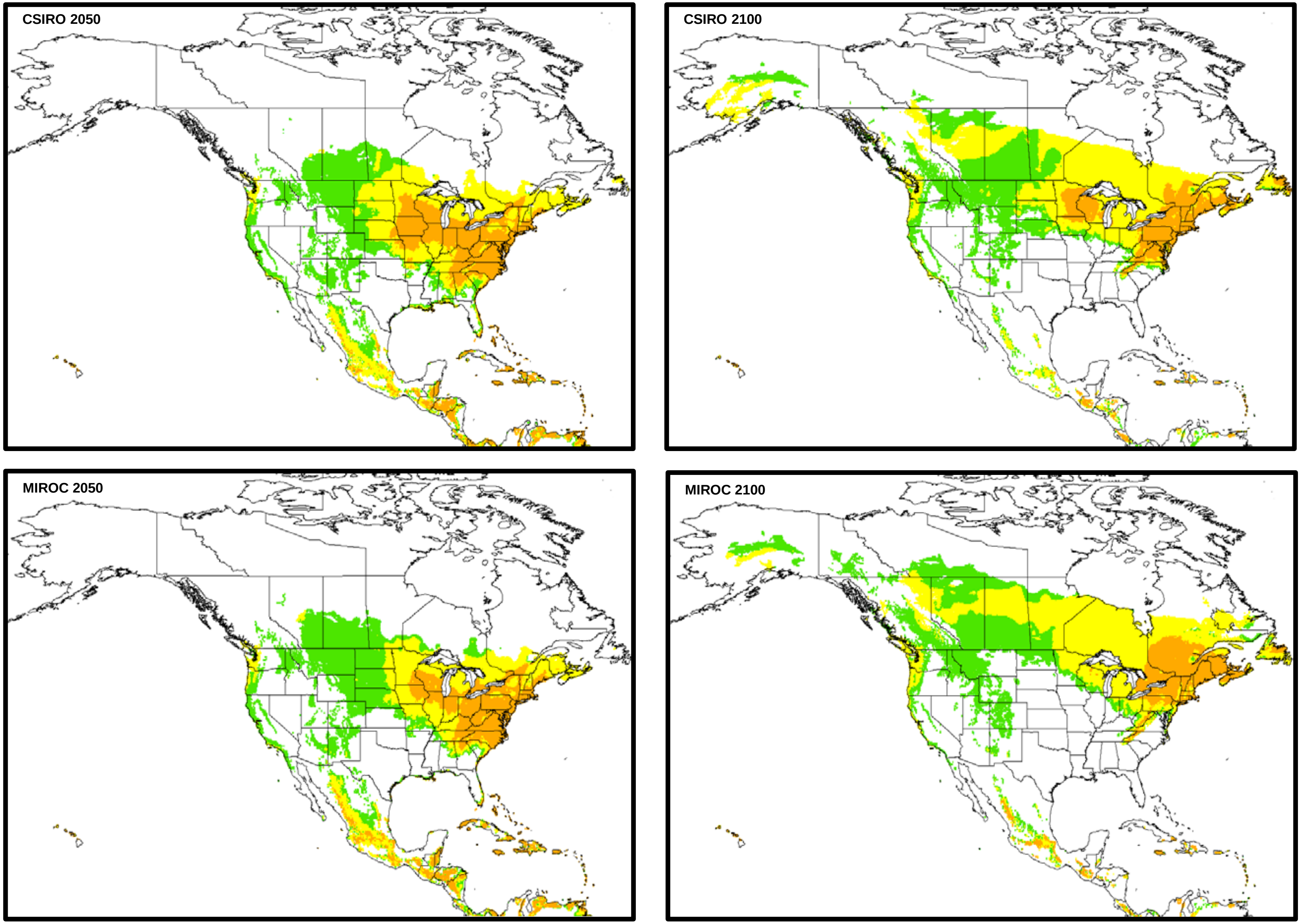


Kistner In Revision (Environ Entomol)

Modelled Ecoclimatic Suitability

Unsuitable (EI < 1) Marginal (EI = 1 - 5) Suitable (EI = 6 -15) Highly suitable (EI > 15)

Modelled Future Climatic Suitability in NA



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