

Global *Halyomorpha halys* establishment: research progress

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Team members

Members list

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Amy Morey

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Sue Worner

Additional members*

To be added here...

** A more complete list will be communicated after including newly added members after this meeting.*

Original project plan/layout

Data/Knowledge – What we know now? What exists now? What has been found out?

- Locational data presences/absences, verification, evaluation, issues around sourcing data.
- More data from native range in China and to Zhu et al.
- Climate data, Climond and other available databases, scale of data
- Biotic data – pest life cycle, predators, parasites, overwintering strategy (indoor/outdoors), plus other information.
- Host maps and issues

Data exploration

SOM analyses of species data

PCA analysis of climate data

Niche stability/expansion analysis

Maxent data exploration

Completed tasks

Not attempted/ongoing tasks

Preliminary result

Models

Phenology model

Climate match and Climex

Maxent

Other correlative models

Multi-modelling approach with Correlative models

MARS

SVM

Random forests

ANN

Consensus or hybrid model

Collecting and cleaning presence data

SI-4: Sources of *Halyomorpha halys* presence records

Geo-referenced point locations where *H. halys* has been reported and confirmed as established were compiled within two different datasets. Unique records were obtained from the following sources:

Source ID	Source	Qty	Duplicate	Remark
1-initial	The USGS Biodiversity Information Serving Our Nation (BISON) online database	23		http://bison.usgs.ornl.gov
2-initial	EDDMapS database	2,742		
3-initial	European Plant Protection Organization (EPPO) report 2013/5	1		reported place names geo-referenced through google earth
4-initial	EPPO report 2014/3	2		reported place names geo-referenced through Google earth™
5-initial	Global Biodiversity Information Facility (GBIF) portal	31		http://www.gbif.org , Presences in USA and Japan
6-initial	Global Invasive Species Information	6	1	www.gisin.org

Initial dataset (hh.set1)

Total = 3,189

After duplicates were removed = 492

Unique to this dataset = 22

Removed locations include: Alaska, Florida and Arizona.

Refined dataset (hh.set2)

Total = 3,384

After duplicates were removed = 547

Unique to this dataset = 77

Added locations include: More locations in Japan



Two *H. halys* potential distribution studies done independently

Senay et al under review

- Has been submitted to the Scientific Reports Journal
- Models:
 - Correlative multi-modelling framework (QDA, LOG, RF, SVM, NNET)

1 Multi-model analysis for projecting the global distribution of
2 *Halyomorpha halys*
3 Senait D. Senay^{1*}, Craig B. Phillips^{2,4}, Ursula Torres³, John Kean^{2,4}, Robert C.
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12 Zealand
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14 ⁴Better Border Biosecurity, www.b3nz.org
15
16 ⁵Northern Research Station, Forest Service, United States Department of Agriculture, 1992
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Senay, S. D., C. B. Phillips, U. Torres, J. Kean, R. C. Venette, and S. P. Worner. submitted. Multi-model analysis for projecting the global distribution of *Halyomorpha halys*.

Kriticos et al 2017

- Has been published in the Journal of Pest Science
- Model:
 - CLIMEX

J Pest Sci
DOI 10.1007/s10340-017-0869-5



ORIGINAL PAPER

The potential global distribution of the brown marmorated stink bug, *Halyomorpha halys*, a critical threat to plant biosecurity

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Abstract The brown marmorated stink bug, *Halyomorpha halys* is a highly polyphagous invasive insect, which has more than 300 reported hosts, including important horticultural crops. It has spread to every Northern Hemisphere continent, most recently to Europe. Whilst there have been no reports of incursions into Southern Hemisphere countries, there have been many interceptions associated with trade and postal goods. We modelled the potential distribution of *H. halys* using CLIMEX, a process-oriented bioclimatic niche model. The model was validated with

independent widespread distribution data in the USA, and more limited data from Europe. The model agreed with all credible distribution data. The few exceptions in the distribution dataset appeared to be transient observations of hitchhikers, or were found at the edge of the range, in regions with topographic relief that was not captured in the climatic datasets used to fit and project the model. There appears to be potential for further spread in North America, particularly in central and southern states of the USA. In Europe, there is substantial potential for further spread, though under historical climate the UK, Ireland, Scandi-

Kriticos, D. J., J. M. Kean, C. B. Phillips, S. D. Senay, H. Acosta, and T. Haye. 2017. The potential global distribution of the brown marmorated stink bug, *Halyomorpha halys*, a critical threat to plant biosecurity. *Journal of Pest Science*:1-11.

Both studies made use of the presence data collected by the establishment group.

CLIMEX model result by Kriticos et al 2017

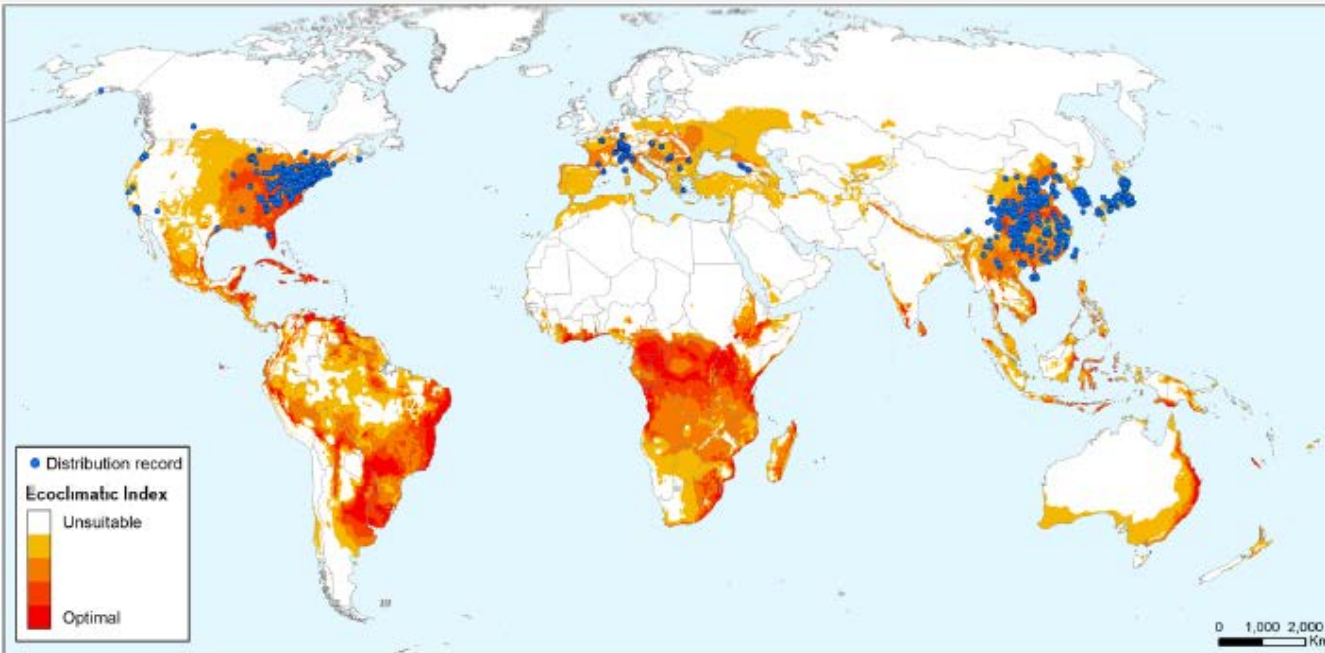


Table 1 CLIMEX parameter values fitted for *Halyomorpha halys*

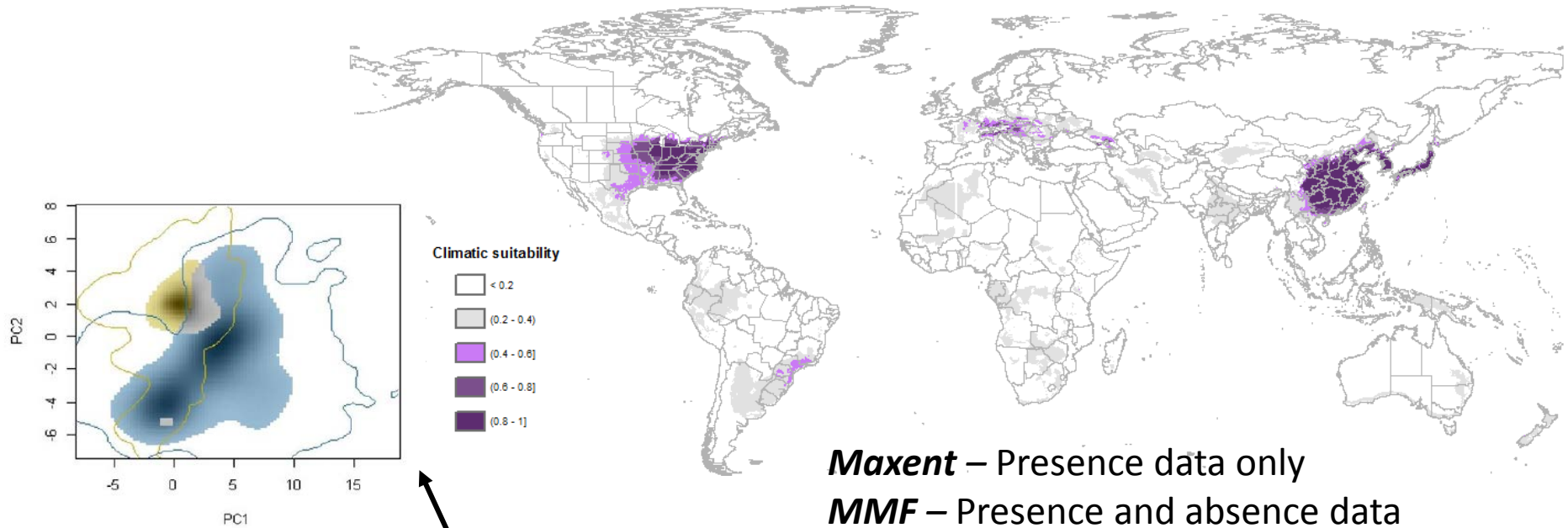
Parameter	Mnemonic	Unit
<i>Temperature requirements</i>		
Limiting low temperature	DV0	12 °C
Lower optimal temperature	DV1	27 °C
Upper optimal temperature	DV2	30 °C
Limiting high temperature	DV3	33 °C
Degree-days per generation	PDD	595 °C days
<i>Soil moisture</i>		
Limiting low soil moisture	SM0	0.1
Lower optimal soil moisture	SM1	0.5
Upper optimal soil moisture	SM2	1
Limiting high soil moisture	SM3	1.5
<i>Diapause</i>		
Diapause induction day length	DPD0	12 h light
Diapause induction temperature	DPT0	5 °C
Diapause termination temperature	DPT1	5 °C
Diapause development days	DPD	0 days
Diapause summer (1) or winter (0)	DPSW	0
<i>Cold stress</i>		
Temperature threshold	TTCS	-18 °C
Stress accumulation rate	THCS	-0.01 Week ⁻¹
<i>Heat stress</i>		
Temperature threshold	TTHS	33 °C
Stress accumulation rate	THHS	0.01 Week ⁻¹
<i>Dry stress</i>		
Threshold soil moisture	SMDS	0.1
Stress accumulation rate	HDS	-0.01 Week ⁻¹
<i>Wet stress</i>		
Threshold soil moisture	SMWS	1.5
Stress accumulation rate	HWS	0.002 Week ⁻¹
<i>Hot-wet stress</i>		
Threshold soil moisture	TTHW	28
Threshold temperature	MTHW	1.5 °C
Stress accumulation rate	PHW	0.007 Week ⁻¹

Take home biosecurity message:

*“The CLIMEX model of *H. halys* indicates the potential for substantial range expansion and infill in Europe and North America”*

“The ineffectiveness of local-scale management techniques means that invasion pathway management is likely to be the only effective means of managing the invasion risks into the Southern Hemisphere.”

Correlative multi-modelling framework (MMF) study result (Senay et al)



First two principal components for environmental variables correlated with the presence of *H. halys* in its native and invaded ranges:

Grey cells - environments occupied in both the native and invaded ranges (stability).

Blue cells - environments occupied in the native range that are not occupied in the invaded range.

Gold cells - occupied invaded environments that are unoccupied, in the native range (expansion).

Maxent – Presence data only

MMF – Presence and absence data

1. Logistic regression (LOG)
2. CART (Classification and Regression Trees)
3. RF (Random Forest)
4. NB (Naive Bayes)
5. SVM (Support Vector Machines)
6. NNET (Artificial Neural Networks)
7. QDA (Quadratic Discriminant Analysis)

- Top 3 models selected based on Kappa score and are combined to give weighted average, best and worst scenarios

Discussion regarding comparison of the two studies

Senay et al under review

- A paper focused on standardizing multi-modelling frameworks using *H. halys* potential global distribution as the case study.

Kriticos et al 2017

- Focused on identifying the global potential climatic suitability for *H. halys*.

Outcomes so far....

- Both studies conformed when it comes to predicting the invaded and native ranges of *H. halys* globally.
- Both studies showed that *H. halys* is expanding its range.
- There are a number of locations where the potential climate suitability projection from these studies do not agree. Discussion is ongoing to identify possible reasons and propose solutions as to how adequately quantify/qualify uncertainty surrounding SDM projections.
- Efforts will be made to share the discussion by releasing formalized comment/response documents as supplemental information along with main outputs if time permits.

Change in *H. halys* pest status..

- *H. halys* has been reported from Georgia (Europe) and Chile (South America) since this project has started both studies have predicted areas within these countries as suitable, further evaluation is needed to confirm if the actual locations of establishment were predicted.

Future plan

- ***Evaluate results from the two studies and the climate matching result from Craig et al.**
- **Explore other model types** (Involves all of the establishment team members)
 - Phenology model (Yula, Richard, John Kean?)
 - Other correlative models (possibly those not covered by Senay et al)
 - Mechanistic models
- **Finalized consensus or hybrid model** (All potentially contribute here)

*The above named individuals are only assigned to organize the listed activities , all members are expected to take part in the exercise/research

Goals to accomplish by end of 2018

- Produce a working paper that details the different steps taken when using the different models to predict the potential distribution of *H. halys*.
 - *Provide technical detail and data so that it is replicable by people who seek training to use these models*
 - *Deposit all data in an open data portal.*
- Document the different methods used and the rationale behind the choices
- Discuss any discrepancy between model results and attempt to characterize reason for variation and recommend different modelling techniques for different data when applicable.
- Produce training material

Beyond 2018....

- Produce a journal article that reports the results of the different *H. halys* establishment risk models, their differences, similarities and recommendations for the optimal use of species distribution models, specific modelling techniques and appropriate model validation.

Other BMSB related projects

A cloud based high-performance computing (HPC) compatible individual-based dispersal (IBM) model is proposed

- If funded the project will look into:
 - Both the self and human mediated dispersal rate, extent and potential of *H. halys* in Minnesota, USA.
 - A set of biological parameters that are needed to parametrize an IBM model are being compiled
 - An open source dispersal model is being assessed for parallelization so that it is compatible to a cloud based HPC environment
 - The dispersal modelling platform will include economic models to assess economic risk from *H. halys* dispersal.
 - The model will be capable of running different dispersal, landscape and management scenarios

Thank you & please join us!

Establishment Group

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