

Objective Prioritization of Exotic Pests (OPEP): Developing a framework for ranking exotic plant pests

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Who are we?

NSF Center for Integrated Pest Management



Raleigh, North Carolina, United States

Who are we?





Why do we need to prioritize the exotic pests?





Spend our limited resources on pests that pose the greatest risk Low Moderate High

Our Stakeholders: Cooperative Agricultural Pest Survey (CAPS)



Risk analysis, evidence, uncertainty and decisionmaking

We wanted the model to be

- Objective evidence-driven, not opinion-driven
- Transparent separates analysis based on scientific information from that based on policy
- Separate uncertainty from risk score
- Flexible can be used to look at risk by region and host

Defendable

How should pests be prioritized?

- 1. Consequences of introduction
 - Is the pest likely to cause serious impacts upon introduction & spread
- 2. Likelihood of introduction

Risk

Pest

- How likely is the pest to enter the United States, establish a viable population?
- 3. Feasibility and Cost Effectiveness
 - Is it **possible** to survey for the pest?
 - Do the expected impacts of the pest justify the cost of a survey program?
- 4. Policy considerations



OPEP: Categorizing by Impact Potential



Training Data and Observed Impacts

- Identified over 100 non-native arthropods and 80 pathogens that have become established in the United States (> 25 years)
- Team of entomologists/pathologists & economists classified each pest/pathogen in terms of its observed impacts in the United States



Impact Potential: Select Criteria

We developed a set of yes/no and multiple choice questions (criteria) we thought might be predictive of impact

Impact Potential - Training data

Pests that were introduced into the U.S.



100 non-native arthropods (Training data)



Impact Potential - Criteria

| When left unmitigated, the organism causes losses up to: |
|--|
| [a] > 50% |
| [b] 26-50% |
| [c] 10-25% |
| [d] < 10% |
| [?] |



Selecting important criteria

Chi-square Test and contingency table



Contingency Table

| | | es7 | | |
|---------|-------|-------|-------|-------|
| Count | ? | no | yes | |
| Total % | | | | |
| Col % | | | | |
| Row % | | | | |
| Low | 11 | 7 | 24 | 42 |
| | 10.89 | 6.93 | 23.76 | 41.58 |
| g | 84.62 | 58.33 | 31.58 | |
| | 26.19 | 16.67 | 57.14 | |
| Medium | 2 | 2 | 26 | 30 |
| 5 | 1.98 | 1.98 | 25.74 | 29.70 |
| | 15.38 | 16.67 | 34.21 | |
| | 6.67 | 6.67 | 86.67 | |
| High | 0 | 3 | 26 | 29 |
| | 0.00 | 2.97 | 25.74 | 28.71 |
| | 0.00 | 25.00 | 34.21 | |
| | 0.00 | 10.34 | 89.66 | |
| | 13 | 12 | 76 | 101 |
| | 12.87 | 11.88 | 75.25 | |



Contingency Table

| | | | es | 11 | | |
|------|---------|-------|--------|-------|-------|-------|
| | Count | ? | NA | no | yes | |
| | Total % | | | | | |
| | Col % | | | | | |
| | Row % | | | | | |
| | Low | 2 | 1 | 35 | 4 | 42 |
| | | 1.98 | 0.99 | 34.65 | 3.96 | 41.58 |
| g | | 33.33 | 100.00 | 42.17 | 36.36 | |
| atir | | 4.76 | 2.38 | 83.33 | 9.52 | |
| S.R | Medium | 4 | 0 | 22 | 4 | 30 |
| j | | 3.96 | 0.00 | 21.78 | 3.96 | 29.70 |
| | | 66.67 | 0.00 | 26.51 | 36.36 | |
| | | 13.33 | 0.00 | 73.33 | 13.33 | |
| | High | 0 | 0 | 26 | 3 | 29 |
| | | 0.00 | 0.00 | 25.74 | 2.97 | 28.71 |
| | | 0.00 | 0.00 | 31.33 | 27.27 | |
| | | 0.00 | 0.00 | 89.66 | 10.34 | |
| | | 6 | 1 | 83 | 11 | 101 |
| | | 5.94 | 0.99 | 82.18 | 10.89 | |

Selected Criteria - Insights

- Number of hosts was not found to be related to impact
- Ability to survive harsh conditions was not found to be related to impact for pathogens

Selected Criteria - Insights

- Best predictor of pest behavior in the United States is behavior outside the U.S. and the level of control/ research on the organism*
- *If an organism is not a pest in its native range & if it has not been introduced into a novel area, we may not be able to make a prediction
- Specific biological characteristics are not as important in predicting impact
 - parthenogenic reproduction
 - ability to serve as vector for plant pathogen

OPEP Impact Potential







Model Use: Consideration of U.S. Conditions

- Are there already organisms in the U.S. that fill the same ecological niche?
- Are there tools in the U.S. that have already been developed and are in use that would be effective at controlling the pest?
- Would current production practices or conditions in the United States be effective at mitigating the pest?

Results

Results (based on logistic regression) are provided as probabilities for a pest resulting in High, Moderate, or Low impact

| Risk Rating and Probabilities | | |
|---------------------------------|----------------------|--|
| Biology and Natural History | 5 | |
| Pest Damage | 15 | |
| Research and Management | 13 | |
| raw score sum | 33 | |
| Impact of Current US Conditions | -5 | |
| zeta1 (Low Medium) | 0.588047 | |
| zeta2 (Medium High) | 2.8025218 | |
| coefficient | 0.05342245 | |
| Risk Score - OLR fitting | 1.495829 | |
| Logit1 | -0.907781 | |
| Logit2 | 1.306693 | |
| Probability (Low) | 28.7454066% | |
| Probability (Moderate) | 49.9505216% | |
| Probability (High) | 21.3040718% | |
| sum | 1 | |
| 95% CI for the high probability | 15.007%~32.760% | |
| Predicted Pest Category | Moderate Impact Pest | |

Uncertainty analysis

We consider uncertainty through a Monte Carlo simulation (5000 iterations) where alternate answers are applied based on uncertainty rating



Model Use: Communicating with stakeholders

- A list of prioritized exotic pest species with the following information
 - Impact potential category
 - Uncertainty

Model Use: Communicating with stakeholders

A summary document encapsulates the assessment with background information, results from the predictive model, endangered area, references, and an appendix with predictive questions & answers

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| Sciencific name CAPS 295A 3333000000 - 1 | detilier bizonine CAPI 7974 20131221 - |

Experts: Just over \$1.3 billion in oak logs and humber are experted worldwide from the U.S. (FAS 2015 couried 5/15/2015) Results from predictive model: Unmidented rick ratios: Minor part. Train that contributed to this rating include long distance nature

dispersal abilities, and a history of causing serious damage to host trees including host mortality, yield losses from reduced productivity and from structural damage to timber. Although it primarily attacks structure trees, it is frequently described as a serious pest and significant research has been conducted relative to its pest status antol. The part is very difficult to control. It is a cryptic forest part and found in environmental stem control of this insect has not been considered practical; pert management involves maintenance of sh vibvicultural management, including thinning of oak forever and timely harvesting of 0005; Hiller 1998). Removal of infected stems has been suggested as a possible means

Independ rick rating: <u>Many yang</u> After considering mitigations that may be present in the United States, the selected part emapory remains minor peer. There is a similar and density related part in the United States, hind lowers the access somewhat, but these area as tools known to be effective at convolting this bupyreation and many provides any likely to have killed to so selflor. The row-land discount lower, <u>decide bioinform</u>, studies. aks in eastern North America (Decce 1985; Manck and Anzieceni 1992 in Ciacle 2003). The ability of A pete successfully with A. bilingenus in oak forests is unknown (Ciaula 2003). We had a low at of uncertainty for this assessment.

P(Major peet) = 21.5% P(Maner peet) = 49.5% P(Manerbrechnid peet) = 28.7%

certainty simulation: The results of the Monte Carlo simulations (5000 iterations) reveal that if the rions were answered differently, the predicted category for Agriles bigoties to would generally



ion: This bupractid is a good attemple of a minor forest past that could tand toward b threshold past (20% probability), oraging relatively little damage in forested eccevatence and helping to break dow

Aprilus hippitatus CAPS PPIA 20151211 -3

od, or one that could become a serious pest (21% probability), given the right set of environmental conditions. I Europe, this hyperstid is generally a secondary peet stacking weakened trees, but tree varying or mortality often depends on whether this species attacks the weakened tree (Morgal and Hileppenels) 2000). Its firm categorization a a minor pest (almost 50% probability) and its history of crusing serious damage in its native range-

Analyse (& summary author's Laslia Nawton, PERAL hate: Darambar 11, 2015

References

- Brown, N., D. J. G. Imward, M. Jagar, and B. Dazman. 2014. A review of Aprilar Sigurature in UK forests and in relationship with none wild define. Foresty 0:1-11. Cleak, W. M. 2000. EXPCR. Dephase Pert Approx. April. Spinnane, USDA Forest Service. Available at:
- (Collemptis: exploration of the second se
- a)us3222221432244 reming, M. C., D. M. Borchart, F. H. Koch, F. J. Sapin, W. D. Smith, R. A. Hanck, and R. D. Magaray. 2010 and an analysis of the statement of the community of the statement tgvilus bigunatus (7800008) i Fechnology Enterprise Team.
- http://www.ft.fted.ins.fter.ord.acd/threaded/technology/www.ins.fter.htm.pre.iduange.chml. Downing, M. G., D. M. Borthert, F. H. Kock, F. J. Sapin, W. D. Smith, R. A. Hanck, and R. D. Magaray. 20100 Aprilese biguineses (Patrices) sample design. Ft. Collins. CO: UDDA, Forest Territor, Forest Teshth. tg-ilus bigunatus (Fabricus) st Fachnology Enterprise Team.
- http://www.fs.fad.us/forewthae3th/technology/investiges_ageDubligestatus_rickmaps_chtml. Hanck, R. A., and R. E. Acciavatti. 1992. Twolined classitud borar. Forest Insect & Disease Lasflet 168. U.S.
- Intole, K. A., and K. L. Aratterini, 1972. Unclusive classific control relation in classific activity of particulars of section 24 particulars of section 24 particulars. Proceedings of the Aratteria Methods, and H. Yu. 2002. The sense of the house a new controp and in North America. Natural Methods and M. Yu. 2002. The sense of the house a new controp and in North America. Natural Methods 2004. Control 1994. A section 24 particular processing of the sense fraction of the Methods 2004. Control 1994. The Method 2004. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. Control 1994. A section 24 particular processing of the Northoly 2004. A section 24 particular processing of the Nor
- aiet, C. 1963. New studies on the manuary of tree cambial ti pethological structures. C.R. Acad. Sci. 257(18):2702-2
- rsea, J. T. 2011. The Biots of North America Program (BONAP). North American Plant Atl (http://www.bonap.org/MapOwinkhourd.html). Chapel Hill, N.C. [maps generated fro.
- camp: www.housp.org.Map/instablesed.ioni), Chaple Hill, N.C. (maps generated from Kartau, J.T. 2000. Resides Synthesis of Nexth America. Variate 1.0. Bion of Nexth America Program (BONAP) (press)). http://www.housp.org/.(Archived at 1928.LL) (a.A., and J. K. Smarpin. 1994. Addas salindinyth evendow heapth, Multico, Warsen, 705 pp.
- v serve Softwar's out trace from mystery disease that's 'blooding them to death' and the int could be to blance, or Mull Caline, July 8, 2013. Low to your Ministry.

- 18 2023. News, L. G., and J. Hilascanaki. 2000. The oak buyweid bards, Agrica Japanese (7) (Col., Buyweides), a researt factor is oak decline in Europe. Journal of Post Science 77: 318-128. USDA APRES. 2011. New Post Europe. Second of Science Research and Bark Bearles. USDA APRES PPQ EDP European Management, Krowitska, Maryland.
- infer, Aprilas bipatatas Febr. and Coracitas

Overall OPEP model





| Knowledge about likelihood of an event | Model probability |
|---|------------------------------------|
| Higher than 0.5 | 0.5 - 1.0 |
| Lower than 0.5 | 0.0 - 0.5 |
| No way the pest will make it | 0.0 |
| Absolutely the pest will make it | 1.0 |
| Not documented in literature | 0.0 - 1.0 |
| Probability (P) well documented | Enter optimum, maximum, minimum |
| Event not applicable for this pest | 1.0 (for practical purposes) |

(10,000 simulations)

High random (any value between 0.5 and 1)

Totally random (any value between 0 and 1)



Low random (any value between 0 and 0.5)





- Attrition increases with the number of events in a pathway (i.e., the more elements the lower the probability of entry, establishment)
- A totally random simulation could estimate probability of entry, establishment if we know the number of events involved (although the spread of the resulting distribution reflects the uncertainty)
- An increase in information for an event (high, low) improves performance

Overall OPEP model



Pest Prioritization Modeling Team

- CPHST PERAL & NCSU CIPM Cooperators
 - **USDA Team Leads**: Alison Neeley, Leslie Newton, Manuel Colunga Garcia
 - ► NC State Pls: Godshen Pallipparambil, Ernie Hain
 - **Economists**: Lynn Garrett, Trang Vo, Alan Burnie
 - Entomologists: Glenn Fowler, Cynthia Landry, Ignacio Baez, Jim Smith, Holly Tuten, Amanda Anderson, Grayson Cave, Robert Mitchell, April Hamblin, Senia Reddiboyina, Douglas McPhie, Jeremy Slone, Alejandro Hector Merchan
 - Plant Pathologists: John Rogers, Lisa Kohl, Amanda Kaye, Betsy Randall-Schadel, Jarrod Morrice, Heather Hartzog, Walter Gutierrez, Andrea Sato, Sofia Pinzi, Jennifer Kalinowski
 - Statistician: ByeongJoon Kim
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- Others
 - APHIS-PPD, CIPM Cooperators