

Bayesian Network Model for Invasive and Injurious Species

**Peer Review Comments and Responses to Comments by:
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This report corresponds to the peer review plan “Use of a Bayesian Network Model as a Decision-Support Tool For Assessing Risk of Nonnative Aquatic Species as Invasive and Injurious Species” posted on USFWS’s Science website on December 19, 2012 (<http://www.fws.gov/science/pdf/Bayes-Net-Peer-Review%20Plan-12-19-12.pdf>)

FWS selected these five peer reviewers for their expertise in one or more disciplines: aquatic zoology, invasive species, risk assessments, aquaculture; and laws, policy, and regulations of organisms in trade.

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Dr. Marcot is an international authority on Bayesian statistics as applied to ecological modeling and conservation. Dr. Marcot worked with the U.S. Fish and Service (FWS) under a cooperative agreement to develop the model and coordinate the peer review. Peer reviewers provided their comments directly to Dr. Marcot, who then compiled them and provided them to FWS without attributions (that is, a “blind” review for FWS; peer reviewers also could not see each other’s comments). The comments of each reviewer are independent and do not necessarily reflect the views of their associated organizations or employers. FWS reviewed the comments and provided the responses. The comments are organized by category.

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Comment only (no response required)

1. Variables seem logical and seem to be linked logically.
2. The Bayesian Network approach seems logical and well-suited to the intended application. It enables synthesis of a lot of disparate information with various uncertainties. The output is not simply a decision support tool but also a record of how information was incorporated. This makes it possible to revisit the decision and explain why it was made. The framework provides decision support and logically organizes available information.
3. The Bayes net model clearly shows factors and interrelationships. This addresses nonlinear (and combinations of) interactions pertinent to the ecology and biology of the species.
4. The model forces you into making discrete decisions about states for each node; not hung up on excessively multiple states within the nodes. Admittedly, I am not the one best equipped to evaluate the number of choices within each node or assign the relative probabilities; however, having fewer choices within a node should compel one to be more thoughtful. One of the issues we ran into with ANSTF 1996 Generic [Risk Assessment] Process was having too many options and thus attempt to refine analysis to point not any easier to assign level of risk or uncertainty.
5. The model structure and approach parallels that of a decision tree by segmenting the causes and conditions that indicate injuriousness. [FWS note: the outcome node from Bayes Net model was changed from “injuriousness” to “invasiveness”. This change was made in response to peer review acknowledging that injurious determinations under the Lacey Act do not only flow from the results of the Bayes Net but require additional administrative rulemaking and decision-making processes. See responses to questions 96 and 123 for additional explanation.]
6. One could use the model to evaluate different outcomes for a given species in various parts of its actual or potential geographic range.
7. The model makes the thinking process very explicit. This is fantastic. It also provides immediate results, so the impact of modifying various inputs is immediately observed.
8. The model is a good approach to take, intuitively, for aquatic species risk assessments. We typically use expert opinion for such risk assessments.
9. In general, the influence network captures well the literature on invasive species.
10. The outcomes of determining harm seem sensible and consistent with the literature.
11. The overall model structure is consistent with what we know about invasion and is defensible. It is, as simple as possible, a map of influence.
12. I initially had questions about some of the intermediate linkages among the variables, but after explanation, I understand why they were so structured. The model structure can

accommodate direct or indirect linkages, and their influence on the final probability of injuriousness depends on the conditional probability table (CPT) values and characteristics.

13. Very clear as to the linkages in the influence diagram.

14. It's a logical progress down this "decision tree." It just lets the software create the relative values, and is based on high degree of reliability (the 50 test species).

15. I like the fact that you can readily look at sensitivity in this model structure.

16. FWS's cautions and caveats all seem germane; the model should be used as part of the decision-making strategy, as it forces people to be very clear about the data they are using for the decision. The model also does a good job at using expert opinions about weightings given to different elements leading to injuriousness rather than doing it anew for each species. This makes it very consistent across species.

17. Other possible information sources have been nicely already incorporated into building the model.

18. The harm side of the model looks good.

19. This isn't a species-trait model per se, but the model incorporates species' biological attributes (e.g., competition, predation) typically associated with invasiveness; e.g., traits such as fecundity, growth rate, and maximum length.

20. No significant oversights or omissions; most comments pertain to inconsistencies or areas of improvement to definitions, etc.

21. This would be a suitable risk assessment tool to be used for regulatory purposes.

22. I do prefer the narrower number of states in this model, as compared with more (excessive numbers of) states (choices) in previous models that lacked justification for so many states and conditions.

Suggested or implied modification of node names, node state names, or change in representation of a node or state, without changing the model structure

23. Rename the "behavioral effect" node; its title is misleading. I would expect effects of or on the species' behavior, and instead it merely pools the impacts of competition and predation. Or, you can eliminate this node if it doesn't add any additional information.

FWS response: The Predation and Competition nodes inform the Behavioral Effect Node. Predation and competition are two factors (behaviors) that directly influence the effect of an introduced species on a native population. We have decided to retain the Behavioral Effect node in this model.

24. Note that the cutoff for the different states in the climate 6 score node entail rounding. Edit the state titles so it is clear which state the cutoff range values pertain to (e.g., 0.005 climate score). [Note: this is made clear in the PDF file of definitions—except that a less-than sign should have been used between 0.005 and X, since X is greater than 0.005, not less than it in the medium state. I see that this same error is present in the cited Standard Operating Procedures posted on the USFWS website.]

FWS response: We have revised the less than signs for Climate 6 score definitions. The error has also been revised in the Standard Operating Procedures that are posted on the FWS website.

25. Reconsider the term “insignificant” in all nodes in the model, to be better listed as something like “intermediate significance” or a term that better connotes intermediate level effects. The term insignificant implies no meaningful effect or influence.

FWS response: We decided to use the terms significant and insignificant because the National Environmental Policy Act (NEPA) is based on the significance of effects of federal actions. NEPA analysis includes an Environmental Assessment (EA), which determines if an action has significant impacts. Those with no significant impacts result in a Finding of No Significant Impact (FONSI). We have decided to continue to refer to state titles as significant and insignificant since these two terms are used in environmental law and policy and documents associated with rule promulgation.

26. Definition of injuriousness gives only two states (no and yes), whereas actual model output is a percentage likelihood. The definition and the model need to match.

FWS response: We have not set a numerical threshold for determining “invasiveness” (renamed from “injuriousness”) because such thresholds may vary among species and issues, and are more in the purview of the risk management actions that would weigh the results of the model with other considerations and mandates that lie beyond this model’s scope and purpose. We added the “Evaluate Further” category to include species that have a low potential for establishment and spread, but a high potential for harm (such as venomous snakes without antivenom) and thus would signal the need to provide further assessment of the species’ potential for invasiveness based on conditions and characteristics not explicitly addressed in the model.

27. Incorporate a broader range of experts to inform the CPT values.

FWS response: We will proceed with advancing the model with its current set of conditional probability table (CPT) values, which are based on the collective discussions and experience of the FWS team.

The model’s performance was initially tested using 50 species with known invasive (injurious) outcomes, and the model performed well. We further propose to implement the model in a next phase of application testing to evaluate how well the model serves as a risk assessment tool within a broader invasive species risk analysis framework within the agency.

The model has also been intensively peer-reviewed by five experts, including the one providing this particular review comment. These peer reviews were conducted as individual blind reviews (where each reviewer was not given information about the other reviewers). The peer reviewers were given opportunities to comment on CPT values of all nodes in the model and to suggest any changes.

Further, the model itself is really more of a risk assessment “rule set” than an ecological prediction tool, and the CPT values therein are currently assigned and calibrated mostly to reflect the agency’s invasive species risk assessment policy and expertise.

28. See paper by Jamie Reaser PhD, on propagule pressure; part of non-human transport? or establishment?

FWS response: Reaser et al. (2008) indicates that propagule pressure is a crucial factor in the establishment of invasive species. Increased non-human transport events inadvertently increase propagule pressure, which in turn increases the probability of establishment. We acknowledge the concepts presented in this paper, but the model is to help inform whether we should consider management actions that reduce the likelihood of species being brought into the country, transported across State lines and subsequently introduced. The model is not explicitly accounting for propagule pressure as part of non-human transport or establishment.

29. Perhaps revisit the naming of the node Behavioral Effect, because it currently implies that the only effects of predators and competitors are on the individual level traits of the responding species rather than on their numerical (abundance) traits. See the distinction of trait-mediated and density-mediated species interactions, for instance, in Werner and Peacor (2003).

FWS response: We have revised definitions and the Behavioral Effect now considers the effect of predation and competition (from the introduced species) on the behavior, health, and abundance of native species. We have reviewed Werner and Peacor (2003) and understand that trait-mediated species interactions are connected to the presence or absence of a species, whereas, density-mediated species interactions account for population density such that a higher population density results in a greater effect on resources. The model, however, is not intended to specifically predict how species interactions will ultimately affect phenotypic or fitness characteristics as mediated by trait plasticity (as advanced by Werner and Peacor 2003). Rather, the aim of the model is to assess potential shorter-term influences of a potentially invasive species. Thus, the Behavioral Effects node is retained to simply combine potential influence of predation and competition.

30. Is Habitat Disturbance better defined as an ecosystem effect? See David Strayer’s (2012) paper on documenting ecosystem level effects.

FWS response: Strayer (2012) defines an effect trait as the ability of a species to change an ecosystem. Habitat disturbance would be an effect trait in that the species is changing the ecosystem. The Habitat Disturbance node (with Predation and Competition) informs the Ecosystem Effect node.

Clarification of: definitions of nodes and states, direction for parameterizing the model to run for a given species, and how results of the model will be used

31. There’s a lot of verbiage in the definitions ... need to be explicit but many adjectives in the definitions are subjective.

FWS response: We have revised our definitions for clarity and cohesiveness.

32. The definitions need further clarification to be more specific. For example, with habitat, the definition lists temperature, food, etc., which are elements pertinent to habitat; but in some other places there needs such clarification, such as with the ecosystem effects node. Needs to be good QC/QA on the prior knowledge going into the inputs, so everyone uses the same terminology and framework. For example, clarify non-native effects on *native* species (need to clarify that the effects are on *native* species, not just “species”). See attachment.

FWS response: The Ecosystem Effect node is the daughter node of the Habitat Disturbance, Predation, and Competition parent nodes such that those three parent nodes inform the Ecosystem Effect node. We have revised definitions to reflect that effects are on *native* species, Federal trust species, and other trust resources and responsibilities (including threatened and endangered species and migratory bird), and State-managed species. We are preparing a User’s Guide that will outline a standard protocol for assessing prior knowledge for the inputs. There will also be an accompanying template spreadsheet for documentation and to record all information and accompanying references. All information informing nodes will be documented in FWS’s Administrative Record.

33. In the definitions, don’t reference 16 USC 544(A); this does not pertain.

FWS response: We agree and have removed all references to 16 USC 544 (A). We have replaced this citation with the National Environmental Policy Act (NEPA) section on “significantly” (see 42 U.S.C. 4371 et seq., 40 CFR 1508.27).

34. [The model needs] more consistency and uniformity in terminology. And simplicity; consider parsing out the definitions to be clearer.

FWS response: See response to Comment 31.

35. Dealing with “uncertainty” within the various nodes is not readily apparent to me, so I may have missed that during briefing. Due to data gaps, it’s not clear if uncertainty resulting from such gaps receives equal treatment or automatically higher percentage of tendency leading to injuriousness. Again, assessors creating the input table should identify degree of uncertainty and explain how dealt with it. Again, transparency explaining data-poor conclusions is important. This best achieved I suspect by detailed comments and references in the comment area of the input tables.

FWS response: Assessors will document all data in a template spreadsheet, which will be part of the Administrative Record. This spreadsheet will include references for this information. A copy of each reference will also be part of the Administrative Record. Assessors will indicate whether there is uncertainty or little information for any input node. “Uncertainty” in overall understanding of how the model’s input variables combine to influence invasiveness was reflected in how probability values were spread across outcomes in each row entry in the conditional probability tables—that is, how combinations of conditions might influence outcomes. “Uncertainty” in the values of input variables for specific species will be reflected by spreading probabilities across states in the input variables (that is, the prior probabilities).

The way the probability structure in the model was parameterized, increasing the uncertainty of species’ conditions (the more that prior probability values are spread among the states in the input nodes in the model), then the more the model will suggest greater uncertainty (evenness of probabilities) of the outcome state of invasiveness, and *not* greater certainty of

invasiveness (injuriousness). Further, the more the number of input variables are depicted with high uncertainty (even probabilities of their states), the more the model is then apt to lean toward “Evaluate Further” as its dominant outcome state.

36. Is FWS considering GMO organisms for injuriousness? (GMO is mentioned within the model node description, but doesn't appear in the PDF definitions file.) I want to be sure that addressing GMOs or not is aligned to FWS's authority. For example, would GMO Atlantic salmon under FDA authority be evaluated by this tool for potential injuriousness?

FWS response: It is the agency's interpretation of title 18 of the Lacey Act that we have authority to consider whether a genetically modified organism (GMO) is injurious to wildlife, wildlife resources, and humans. Therefore, a GMO can be considered with this Bayesian network model. We have added GMOs to the Genetics node definition.

37. Most of the value of the climate 6 score falls into the “high” state, that is, 0.103 to 1 score values. Is this appropriate? Including nearly 90% of the range into the high category will tend to increase estimates of injuriousness for species that have relatively low climate-matching (e.g., 0.11 out of a possible 1). This same relationship appears in the SOP cited in the definitions document, although I found no explanation for why it is so. There may be a good reason, but I would like to see it explained.

FWS response: These categories were based on an analysis of data for 255 species established in 10 countries (Bomford 2008). The Climate 6 scores showed that even species with near 0 Climate 6 scores became established. The FWS approach was to use those scores to graph Climate 6 in relation to Bomford's probability of establishment (PESTAB) (Figure 1), and then develop categorical climate categories based on statistical categories. The statistical categories were developed (*a priori*) before the graph was developed. Statistical categories presently used by FWS are: 1) rejection of 95 percent of the established populations or scores, and 2) rejection of 80 percent of the established populations or scores (Table 1). Thus, the statistical approach is based on rejection of percentages of species established in 10 countries. That statistical approach can be modified, based on the tolerance of risk assessors and risk managers. However, our approach was objective and statistical (and documented in Table 1). Note the example for the climate match score of bighead carp in the U.S. is based on only the native range. That example illustrates that bighead carp, which has become established widely in the United States, was scored at < 0.4.

We also note that Climate 6 scores are only a portion of the climate analysis, but scores are needed to provide a scoring index of climate niche that matches with the target region (typically the 48 contiguous States, but could be adjusted to include Alaska, Hawaii, and territories). In addition to the scores, each species' climate match is illustrated on a map of the target region. Climate matches of 6 and above are shown on that map, so risk assessors and risk managers can evaluate the spatial extent of high climate match in the United States. That spatial information will be helpful, along with the scores, in supporting decisions on which, if any, risk management approaches are proposed for implementation.

Figure 1. Probability of establishment and Climate 6 scores (Bomford 2008), and Fish and Wildlife Service-developed, statistically-based Climate 6 risk categories for 255 species established in 10 countries.

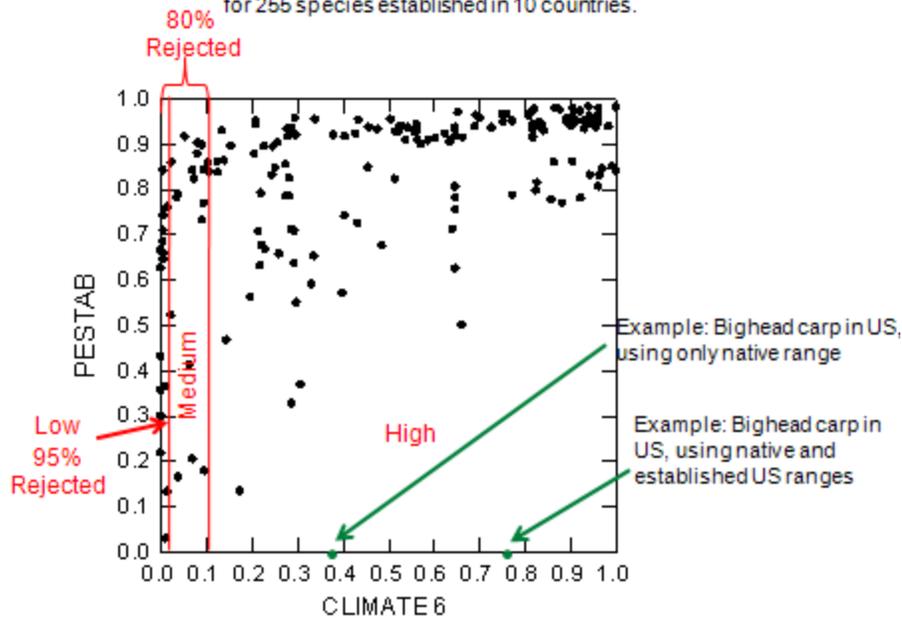


Table 1. Climate 6 Score, and its relationship with Climate Match Category. These relationships were based on analysis of data for 255 species established in 10 countries (Bomford 2008). See Figure 1 for more details about how the climate match categories were derived.

Climate 6: Proportion of (Sum of Climate Scores 6-10)/(Sum of total Climate Scores)	Climate Match Category
$0.000 \leq X \leq 0.005$	Low
$0.005 < X < 0.103$	Medium
≥ 0.103	High

38. The overall model is intended to be generic, thus pertaining to all of the United States. So is the climate 6 score weighted by its values within each proportion of area that the species does or could occupy? (How is the score calculated?) Is the score averaged over the entire geographic extent of the U.S.? The definition needs to be far clearer.

FWS response: The approach used for computing FWS’s Climate 6 scores is identical to that developed by Bomford (2008). Climate 6 scores are not weighted. Instead, the scores are calculated for the target region (typically the contiguous U.S.). To calculate, source weather station data are matched with that for each weather station in the contiguous U.S. Then the number of weather stations that are scored 6-10 are divided by the total number of weather stations. The result is a Climate 6 score for the target region. That score is calculated as a proportion of weather stations in the climate 6-10 range in relation to the total number of weather stations in the target area. Therefore, the score ranges from 0 to 1.0.

39. Is the climate 6 score based on historic data? Should or can climate change be addressed in this model at all, or is to be addressed outside the model? Climate changes can alter suitability for the species over time.

FWS response: All of our climate matching, to date, is based on the CLIMATCH tool (Australian Bureau of Rural Sciences 2013), which contains only historical weather data for the world outside of Australia. Therefore, climate niche mapping under climate change is not possible, using CLIMATCH, for locations outside of Australia. FWS has developed a system very similar to the CLIMATCH tool. That new tool, which will be peer reviewed, does allow for climate niche mapping and scoring under climate change through 2080. Additional consideration would need to be given to projecting future conditions of other input variables in the model, if future climate conditions were to be considered.

40. In the model, does a species need to be established before it can spread? That appears to be the case based on the definitions you use and is consistent with standard usage. So, if spread can't happen independently of establishment, it shouldn't appear as an independent factor contributing to injuriousness.

FWS response: The establishment and spread node are deliberately independent of each other. While the progression from establishment, spread, and harm occurs in most cases of invasiveness, it is not true in all cases. A species may become established, but not spread, and still cause harm to the environment. For example, venomous snakes (from other continents) for which no antivenom exists in the United States can cause harm to humans or native species, which have no defense against them. Conversely, a species may not be established, but can spread and can cause harm to the environment. This case was part of the agency's justification for its injurious wildlife determination of triploid forms of black carp¹. The definitions do not suggest that establishment and spread are dependent on each other.

41. In the definition for spread, does "agriculture" also include aquaculture, pet trade, etc.? I think it should, but the model should state that explicitly.

FWS response: Spread is intended to include, among other things, human transport (any vector by which humans can move fish between States or among large aquatic ecosystems as defined by USGS' 2-digit Hydraulic Unit Codes or regions). Human transport could include agriculture, aquaculture, the pet trade, and other vectors.

42. Does the contribution of medium or high establishment, medium or high spread, AND high harm necessary to get a high injurious outcome, meet FWS' needs?

Also, consider the case when establishment and spread are set to low potential but harm is significant; then injuriousness is 25% yes; does this make sense? Would such a species ever get attention? This might pertain to a non-invasive yet harmful species; in such a case, the model would not identify injuriousness as a high or even dominant probability.

¹ http://www.fws.gov/injuriouswildlife/pdf_files/black_carp_final_rule.pdf

FWS response: First, to clarify, further evaluation of invasiveness of a species would result from a species with significant harm when potential for establishment is low (mostly regardless of the potential for spread). This is the outcome under the model as revised (March 2014), not as reviewed. The above review comment is correct for pre-revision version of the model.

As per the above review comment, in the currently revised version of the model, if establishment and spread are both set to low potential and harm is set to significant, the invasiveness outcome now appears as 70% “evaluate further,” 25% “no” (i.e., not invasive), and 5% “yes” (i.e., is invasive). In this case, the species indeed would likely to get “attention” because of the high probability of needing to evaluate it further.

As an example, if an animal has low risk of establishment and spread, the agency may pursue rule promulgation if it causes harm (as in snakes without antivenin) or hosts pathogens (causing disease). Such species would be considered under the “Evaluate Further” state for the final node of Invasiveness (*note that the “Evaluate Further” state in the “Invasiveness” outcome node of the model was not present in the form of the model reviewed by the experts; this state was added after the peer reviews in response to this and other comments*). For the most part, FWS is interested in species that establish and spread outside of their native ecosystems. FWS did list salmonids without a health certificate as injurious, but only because some pathogens they may carry could establish and spread. Special case exceptions will be looked at regardless of model output for invasiveness. Note that “Injuriousness” has been changed to “Invasiveness” in the model and FWS would still need to address whether a species is injurious after this decision model.

43. Since one of the drivers for developing the model is limited human resources for manually analyzing species with uncertain injuriousness, FWS should confirm that it is indeed more efficient than the manual approach.

FWS response: The model will save time. The model will help prioritize species to be addressed for invasiveness (injuriousness). It also allows structured and repeatable assessments using quantitative and qualitative data and expert opinion that will help inform Service decisions. Further, any “manual” approach should still evaluate the same or quite similar sets of species’ attributes that, with little extra effort, can be expressed in a form that would provide inputs to the model. The model also can be saved with the specific results of a species and used as clear and repeatable documentation of the risk associated with a species’ invasiveness.

44. While I see this model as being very helpful in explicitly informing the decision-making process for listing injurious species, I would prefer to know how FWS intends to use the results of the model. For example, will they be considering for injuriousness only the “n” highest scoring species or those in the top “x” percentile? That sort of relative scoring is different than if they will consider all those scoring above a certain threshold. I suggest that FWS test out different approaches and determine a priori which allows them to best meet their needs.

FWS response: FWS will likely focus first on high risk species as determined by Ecological Risk Screening Summary (ERSS) (those with a history of invasiveness and risk of establishment and spread). The Bayesian network model will help prioritize species with uncertain risk and to identify those that merit subsequent injurious evaluation. Once we run a species through the model, we can see how species rank against each other. This will help us evaluate the relative risk of a number of uncertain species. At this point, we do not have a set

threshold for evaluating species. Subsequent injurious wildlife evaluation would need to address any species run through the Bayesian network model before determining the future prohibition of any species.

45. Why do you need establishment and spread if they do not contribute to injuriousness when harm is insignificant? I found this confusing.

FWS response: This can be addressed in model documentation, that is: the basis of running the Bayes model is when the outcome of the ERSS model is “uncertain” invasiveness. In that case, establishment and spread are pertinent in the current model. A species can establish or spread or both, but may or may not cause harm. All three factors inform invasiveness.

46. [I] want to check unpublished criteria for FWS.

FWS response: Our Injurious Wildlife Evaluation Criteria are published in the Final Rule listing for Three Python Species and One Anaconda Species as Injurious Reptiles ([77 FR 3330](#); January 23, 2012). These are the current listing criteria. See: <http://www.fws.gov/policy/library/2012/2012-1155.pdf>.

47. [You] should compare the model structure carefully to FWS’ historical criteria for injurious *aquatic* organisms; should some definitions be more inclusive? For example, ensure that habitat includes all pertinent factors. Ensure the terminology is pertinent to the taxa intended; terminology needs to be harmonized.

FWS response: The Bayesian network model was constructed to determine the invasive risk of fish species. The factors and parameters included are believed to be the best predictors of risk. We revised the definitions for clarity and cohesiveness.

48. Why aren’t the comments and citations (in the definitions file) for the Harm node included in the definitions of the states?

FWS response: We revised the definitions of the states.

49. In the definitions of the states for the Establishment node, what is “location”; does this refer to the U.S.?

FWS response: “Location” refers to an actual or potential geographic occurrence of the species, where occurrence can be defined on a species-specific basis according to the scope or scale (or both) of geographic resolution pertinent to various aspects of the species’ life history, including, but not limited to, dispersal capabilities, body size, and movement patterns. We have added this explanation to the Comments and Citations section of the Establishment node definition.

50. Considering traditional approaches of arrival, survival, establishment, and spread, this traditional approach assumes that the species has arrived with sufficient propagule pressure to potentially become injurious. If this is the initial assumption for the Bayesian network model, this is fine, but if so, it should be made explicit.

FWS response: The model is intended to help inform whether we should consider management actions that reduce the probability of a species being brought into the country and subsequently introduced. There was an underlying assumption that the species could be coming

in with sufficient propagule pressure to potentially become established. We added this assumption to our documentation.

51. For species, especially those in the test case (of 50 species known to be either injurious or not injurious), what is the probability of arrival? Would it be important to exclude species with low probability of arrival, or low propagule pressure, so as to never become injurious?

FWS response: The probability of arrival is not pertinent to the model. The model is intended to help determine whether a species, if introduced or brought into the U.S., would become invasive. As such, there is an underlying assumption that the species could be coming into the country with sufficient propagule pressure to potentially become established (that is, its “arrival” would be presumed).

52. There may be some cases where some species can survive but not become established, but still become injurious due to long life span and negative impact. This isn’t represented in the model.

FWS response: With the model, as reviewed, an organism that causes significant harm, but has a low potential for establishment and spread results in an assessment for invasiveness of 70 “Evaluate Further,” 25 “No,” and 5 “Yes.” We have added an additional state of “Evaluate Further” to the final node of invasiveness (and reworded the two other states as No and Yes, respectively). The new “Evaluate Further” state will consider those species that have a low potential for establishment and spread, but cause significant harm. A species that causes significant harm, but has a medium potential for spread and low potential for establishment would result in an invasiveness assessment of 80 “Evaluate Further,” 5 “No,” and 15 “Yes.” A species that causes significant harm and has a high potential for spread and low potential for establishment would result in an invasiveness assessment of 70 “Evaluate Further,” 5 “No,” and 25 “Yes.” FWS does not have a specified threshold (number) for the invasiveness node that would trigger an evaluation for Injurious (using the Injurious Wildlife Evaluation Criteria). A species that causes significant harm, but is not established could still be considered for an injurious wildlife listing. For example, triploid black carp may not establish, but may cause harm given their long life span and invasive characteristics. See also response to Comment #40.

53. Establishment occurs before spread; how do experts view establishment vs. spread in terms of importance to injuriousness? Is this really that important? Is injuriousness enhanced because of spread? Also, spread is related to spatial scale; if the scale of spread in the model pertains to the U.S., this means something different than if it pertains to small regions or individual States, for instance.

FWS response: Both establishment and spread are included in the “Factors that contribute to being considered injurious” within the Injurious Wildlife Evaluation Criteria. An established invasive species competes with native species for habitat and resources. Spread suggests that the species is able to increase its nonnative range affecting other habitats and native species populations. The model is designed for a U.S. spatial scale. Stakeholders interested in particular regions or individual States can refer to the climate match output map to determine the level of climate match in a specific region or State. Invasiveness and injuriousness may be enhanced because of spread.

54. Do you need the probability of introduction and harm in a single model? The harm side looks good; the question is, does the species become established? Also, do we need the spread component?

FWS response: We chose to include the probability of establishment and spread along with harm into this model. Climate 6 and Habitat Suitability node outcomes influence the Establishment node. Both establishment and spread are important factors influencing a species' invasiveness. A species may establish but not spread and still cause harm. Alternatively, a species may spread, but not establish and cause harm. See also response to Comment #40.

55. Definitions of the states are subjective and could be interpreted differently by different experts, such as the interpretation of the phrase "minor way" as appearing in the competition node for the "insignificant" state. Instead, threshold values could be provided that would be less ambiguous, such as values of no. of individuals or other quantifications.

FWS response: We have revised definitions to explain what is meant by "minor way." State definitions for insignificant now read "one of more species' habitat(s) negatively affected but in a minor way; for example, the effect is present only during a non-critical period of the effect is at such a low level it does not alter the behavior and health or abundance of potentially affected species." Potentially affected species are defined in the Comments and Citations section.

Further, risk assessors will document all data in a template spreadsheet, which will be part of the Administrative Record. This spreadsheet will include references for information that supported a node's determination. The agency is also putting together a User's Guide that will outline a standard protocol for assessing node inputs. A risk assessor's findings will also be part of the Administrative Record and our assessment will undergo peer review – if appropriate – during rule promulgation stages. See responses to questions 32 and 35.

56. The terms "insignificant" and "significant" are typically used in a statistical sense. [You] may want to consider using different terms, such as low, high, etc.

FWS response: We decided to use the terms significant and insignificant because the National Environmental Policy Act (NEPA) is based on the significance of effects of Federal actions. In general, NEPA analysis may include an Environmental Assessment (EA) to determine if a Federal action may have a significant impact on the human environment. Actions with no significant impacts result in a Finding of No Significant Impact (FONSI). We have decided to continue to refer to state titles as significant and insignificant since these two terms are used in environmental law and policy and documents associated with rule promulgation. (see 42 U.S.C. 4371 et seq., 40 CFR 1508.27). Note that we are simply using the NEPA terms, independent of whether we would need to prepare an Environmental Assessment for a species that we would consider for listing as injurious. As we proceed with further documentation of the model, we will clarify that these terms are used in the context of such policy and not to connote statistical confidence.

57. The team needs to document the underlying scientific basis for making their value decisions when initially parameterizing the probability tables in the model. The key need is to fully disclose and explain what led to their making that decision. By revealing what they relied upon,

it reveals any potential bias in data or literature selection. How do you explain the methodology to be clearly understood by the public when used as part of a tool in a decision-making process?

FWS response: We are preparing an accompanying User's Guide that will outline a standard protocol for assessing prior knowledge for the inputs, as well as clear and full definitions of each node (variable) in the model and their various states. There will also be a template spreadsheet for documentation to record all information and accompanying references pertaining to the probability values for the states of all in the input nodes in the model (e.g., habitat disturbance, predation, competition, genetics, etc.) for each species being evaluated. All information and interpretations used for informing nodes will be documented in FWS's Administrative Record. Also, see response to question 60 for additional details about the clarification of the CPTs in our node and node-state definitions.

58. Inasmuch as the "priors" heavily influence the other nodes, language requiring the importance of creating a detailed, inclusive and clear administrative record of materials/sources investigated whether or not relied upon.

FWS response: See response to Comment 57.

59. I have no real issues with how variables combine probabilities, although there is some concern with the definitions used to develop the prior probabilities of the input nodes.

FWS response: We have revised our definitions for clarity and cohesiveness.

60. The CPTs take multiple inputs and provide an output that seems to me to range from additive to multiplicative. By additive, I mean that small values of several inputs might sum together to generate an output greater than any single input. In contrast, another way of thinking of multiplicative is that there is some limiting factor, so that the output was dependent primarily on the value of one of the inputs (and if it was low, this would reduce the output level regardless of other inputs). Put another way, a multiplicative approach might entail specifying the CPT as per some "limiting factor" influence whereby only one or few of the input nodes cause a change in the probability outcome, whereas a more intuitively additive approach would use additions of risk rather than a limiting factor approach. It may be helpful for the team to think explicitly about whether they expect inputs to add together or to act as limiting factors, then see if the CPTs are actually structured to generate that sort of transformation. Such clarification would be useful for communicating the structure of the model and the thinking of the experts.

Here are two examples – Personally, I would expect species-level effects to be additive, that is, small insignificant predation and competition and genetic and pathogen effects could actually sum to an overall significant effect. (Note, when we checked this online, it didn't work out this way. Insignificant inputs became an insignificant species-level effect. That may be fine, but worth talking about within the team.)

FWS response: As the probability table values were assigned for each node by the team, the team indeed considered specifically how the inputs to each node (the "parent" nodes) should be combined – that is, as limiting or mutually conditioning factors, as monotonic or multimodal relations, as linear or nonlinear relations, and as discrete step functions or discretized continuous functions. For example, in some cases a more limiting-factor approach seemed more appropriate whereby a positive value of at least one parent node would be sufficient to trigger a specific outcome. In other cases, a more mediated approach seemed appropriate.

Such rationale that the team used to assign probability values is reflected in the node and node-state definitions, and has been clarified in our model documentation. We agree this is useful for explaining the model and its construction.

Also, as a point of clarification, Bayesian network models can be constructed by considering the conditional probability values of each node independently of those of other nodes; the model's underlying mechanics and Bayesian equations serve to then combine the information (probability values) among the nodes. This is actually an advantage of the approach so that the model-builder does not need to consider all possible combinations of all states among all nodes at the same time.

61. As another example of the above comment, the injurious node is a (direct) function of establishment, spread, and harm, and it seems (if I remember correctly) that if any one of these components were insignificant, then injuriousness was also insignificant. Thus, [it is] more of a multiplicative CPT, by my definitions above. The exception may have been that significant harm translated into significant risk of injuriousness even if establishment and spread were unlikely.

FWS response: We have revised our state outcomes for the “Invasiveness” (formerly “Injuriousness”) node to “No,” “Yes,” and “Evaluate Further.” “Evaluate Further” will include species that have low potential for establishment and spread, but cause significant harm. Species will receive a numeric score for invasiveness, which will aid in ranking and prioritizing assessed species.

62. For the Climate 6 score node, provide written comments on what each of the state numeric index ranges represent.

FWS response: See response to Comment 37.

63. The temporal and spatial aspects of the model need to be more clearly defined.

FWS response: The spatial scale is the entire United States. However, stakeholders interested in a regional or smaller scale can refer to the climate match output map to gauge the level of climate match to a specific region or State. This climate match output map is included in each species' ERSS, which is part of the Administrative Record and assessment documentation. Furthermore, the scale needs to be at a level that is meaningful for federal authorities and responsibilities. For example, injurious wildlife designations prohibit interstate transport and therefore habitat disturbances would need to occur among two or more states or other jurisdictional boundaries. Jurisdictional boundaries are not restricted to State boundaries, but can also include Tribal, national, and local jurisdictions. We have added spatial criteria to some of the definitions in the model, including for example, spread. We have defined spread in spatial terms as that occurring between 2-digit Hydraulic Unit Codes or regions in addition to occurring between two or more States. FWS can still assess risks within one state should a Federal nexus, such as a federally listed endangered species be imperiled by the introduction of the assessed species. Additionally, our assessment is time invariant, and there is no need to specify a certain time limit for an invasion.

64. Defining “harm” has been a major problem. For example, define “minor way” in the state definition for the harm node. For example, “beyond the range” needs definition; does this refer

to just the native range? Can it pertain to species that are already native within the U.S. that can become invasive elsewhere WITHIN the U.S.?

FWS response: We have provided definition clarifications for “minor way” and “beyond the range.” This model can pertain to species already native to the US that may become invasive elsewhere.

65. [I] assume [you are] relying on the terms from E.O. 13112 that defines invasive species as "...an alien (or non-native) species whose introduction does, or is likely to cause economic or environmental harm or harm to human health". In the Executive Summary of the National Invasive Species Management Plan (NISMP), the term invasive species is further clarified and defined as “a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.” Therefore, are assessors (when inserting percentage of significance, insignificance, etc. for habitat destruction, predation, competition, etc.) considering impacts on the entire U.S. as an ecosystem or on subregions, such as the Southeast U.S., which has been more prone than other parts of U.S. to certain invasives? How would they document the scope of their assessment?

FWS response: The Bayesian network model defines an invasive species as “an alien (nonnative) species whose introduction does or is likely to cause environmental harm or harm to human health” (Executive Order 13112). In rapid screening (ERSS results), our default climate match target area is the contiguous U.S. Thus, the standardized approach to developing the Climate 6 score (for the Bayesian network model) uses that geographic construct. This climate matching does not use only a score, but includes a map that displays the Climate 6 score for each weather station in the contiguous U.S. Therefore, any risk analyst (or stakeholder) can review the map and assess Climate 6 scores for any geographic construct (that is, ecosystem, state, HUC, or basin). The Climate 6 node assesses the climate match of the species throughout the contiguous U.S. The scope of each assessment will be clearly documented in the template spreadsheet that will be part of FWS’s Administrative Record.

66. How will the managers use the model results? They will want guidance on what the numbers mean. More specifically, what is the magic number (probability of injuriousness)? [You] need to provide the context for that number (probability of injuriousness). [You] need to think about how to communicate results to managers. Thresholds may rely on risk tolerance.

FWS response: This model will help inform priorities for uncertain risk species and additional post-hoc analysis will help determine priorities for injurious wildlife listings. We will provide justification for regulatory decisions to the public as part of the regulatory promulgation process.

67. Species could be prioritized for action based on their injuriousness scores, but can species be, or need to be, prioritized across taxa?

FWS response: The Bayesian network model is a freshwater fish species model. As additional models are developed and reviewed, we can consider assessing the invasiveness of other taxa.

68. There are some problems (confusion) with the definitions of nodes and their states. As examples: reference to Federal trust resources is confusing, and the definition of the

“significant” state in the habitat disturbance node is confusing. The definitions of nodes and states need to be straight forward.

FWS response: We have refined and further clarified the definition. See also response to Comment 55.

69. Develop a guidance document (user’s guide).

FWS response: We are currently developing a User’s Guide.

70. There is no guidance on spatial scale in the definitions document. For example, habitat disturbance is over what spatial scale? The entire U.S., some portion ... ?

FWS response: See the response to Comments 63 and 65. This model is going to be mainly used to assess “uncertain risk species” as defined by ERSS. Many of these species have not been introduced into the United States, but have a history of invasiveness elsewhere. Therefore, documented habitat disturbances in the U.S. are unlikely. Information for Habitat Disturbance node would be documented within its nonnative range.

71. [I have a] concern about the term “minor way” in the habitat disturbance, predation, competition, and other nodes.

FWS response: We have revised and clarified definitions. See response to Comment 55.

72. In the definition of the competition node, it mentions predation in the comments section; this was probably meant to refer to competition here. Probably also meant space instead of water in the competition definition.

FWS response: We have revised the Comments and Citations section to replace predation with competition. We have revised the definition to read “food, space, and habitat.”

73. In the definition for genetics, should there be an “or” after the congeners statement? Clarify what combination of conditions pertain in relation to State-managed species.

FWS response: We have revised the definition and moved “no native congeners” to the “None” state outcome.

74. Under human transport, where would something like canals fit in? This needs to fit in somewhere.

FWS response: Human transport includes pipelines and canals. We have added canals to the Comments and Citations section of the Human Transport node definition.

75. In the climate 6 score node, I don’t understand how FWS came up with the numeric thresholds; the source paper has a threshold of 0.2 between established and non-established species.

If you are using the U.S. as the climate “target” for this node, if even large portions of the U.S. are highly suitable for the species, the score could be watered down by unsuitable portions such that, overall, the climate match would be deemed low. When this happens, it underestimates the suitability of some parts of the US. So climate match is very much dependent

on the spatial scale of the target. Could potentially be a very big problem. [I] would recommend doing climate matching at the regional scale.

FWS response: The climate match approach we use typically considers the contiguous U.S. as the target region. As noted previously (response to Comment 40) climate scoring is only one of the products that results from the climate matching process. The other important product that results from the climate matching is a map that shows which regions have a high, medium, and low climate match with the source locations. Any risk analyst (or stakeholder) can review the map, and assess Climate 6 scores for any geographic construct (that is, ecosystem, state, or basin).

76. In the habitat suitability node, the definitions of the states are unclear and clumsy. There, again, is a scale dependency for this node; how much habitat do you need for habitat to be significant, for instance?

FWS response: See response to Comment 63.

77. It would be useful, in the ecosystem effect node, to better clarify the state definitions; for example, what do “negatively affected” and “minor way” mean? It would be useful to give examples.

FWS response: See response to Comment 55.

78. In the behavioral effect node and other nodes, “substantially” is a very subjective term and needs clarity.

FWS response: We have removed substantially from insignificant state definitions.

79. In the transport node, definition wording for the state “seldom” is not consistent with the definition for the human transport node. The key problem is the word “interest;” humans may be totally oblivious to transporting organisms, and interest is not the point and is not appropriate for the definition. On the other hand, the medium state definition is good because it gives an example.

FWS response: Wording is now consistent between the Transport and Human Transport node. We have revised the definition of the Transport node.

80. In the establishment node, [I] need clarification on scale; is this U.S. wide, assumedly?

FWS response: See response to Comment 63.

81. In the spread node, there is no assumption that establishment has occurred. Spread is disconnected from establishment. This doesn’t seem right. Also, the definition of medium potential of spread is long-winded.

FWS response: Spread may happen independent of establishment and vice versa. See response to Comment 40.

82. [The model] should be part of a suite of tools for advising decisions.

FWS response: We agree. The Bayesian network model will be used in conjunction with the ERSS and other information used to assess a species ability to establish, spread, and

cause harm. For a species to be listed as injurious under the Lacey Act, it will still need to meet the Injurious Wildlife Evaluation Criteria.

83. The BN model and the ERSS model are not fully independent because the climate score is used for both. What are the implications of this?

FWS response: ERSS and Bayesian network model projections are not intended to be independent in use of data. ERSSs are intended to rapidly assess species as low, high, and uncertain risk. Bayesian network model evaluations and projections are intended as a decision support tool when ERSS categorizes a species risk as uncertain. Climate niche scoring and mapping are valuable tools. We will use that process in the ERSS, the Bayesian network model, and possibly other decision support tools.

84. Explanation of inputs is key, including if an input state is “none.”

FWS response: Explanation of inputs will be available in the template spreadsheet that will become part of the Administrative Record and will be addressed as part of the User’s Guide. Assessors will clearly document information with respective references and whether there is uncertainty or lack of information.

85. This [model] comprises a readily accessible tool if initial input conclusions documented sufficiently for transparency.

FWS response: See responses above on the User’s Guide, template spreadsheet, and Administrative Record (responses to Comments 35, 63, and 88).

86. Explaining the input information, literature and database searches, justification of conclusions, etc. is key to helping FWS utilize conclusions as well as provide details for stakeholders reviewing the outcomes.

FWS response: See response to Comment 57.

87. I like that the definitions used in the model are accessible via the tool itself (although some needed updating), as are the underlying conditional probability tables. These features make the tool much more transparent to the new user. One term’s definition bears improvement: the definition of predation should state “the capacity of the nonnative species to *prey* on affected species, adversely affecting populations.” “Predate” means to come before or precede in date and I don’t think that’s what the authors intended.

FWS response: We have changed the definition to “the nonnative species to *prey* on affected species”. Also, we will copy all definitions of nodes and their states directly into the documentation in the model itself.

88. I like that the model allows incorporation of ‘rectangular distributions’ to reflect uncertainty for various input nodes. The model output should be characterized not only by the score, but also, qualitatively, by listing those factors for which no information was available. Doing so would improve the transparency of the model.

FWS response: See response to Comments 35, 57, and 84.

Suggested or implied change to model structure (add, delete, modify nodes to require changes in underlying probability tables)

89. The input nodes successfully represent species traits that are recognized within the discipline of invasion biology to influence impact. Well done identifying key species traits to include – especially those related to likelihood of establishment, spread, and various ways in which a novel species could influence its environment.

There are two types of input nodes that are conspicuously absent – those related to demographic rates of the non-native species, and those related to any sort of biotic resistance on the part of the recipient environment. In the invasion biology literature, both of these sorts of factors have been tested for possible relationships with success of non-native species (where success is variously interpreted as establishment or population growth/ density). However, I am not concerned about their absence from this model—as an example, it seems much more important to know whether there is a climate match for a species than its fecundity in predicting whether it will be injurious; similarly, it seems much more important to know whether it is likely to eat a species of concern in the U.S. than whether there is a species in the U.S. that might eat the non-native species and potentially keep it sufficiently in check that it would not be injurious.

FWS response: The reviewer points out potential, additional input nodes that could be included but concedes that the absence of these nodes does not cause concern. No modification of the model is implied. Demographic rates are partially accounted for, but not the biotic resistance of the recipient ecological system. The demographic effects are absent from this model, but may be inferred from the predation, competition, and habitat suitability nodes. Thus, demographic rates are accounted for in a variety of locations, but not specifically specified. The model does not include recipient ecological systems.

90. Where are biocontrol issues denoted, especially regarding genetics? How do you deal with a nonnative species introduced as a biocontrol species? (Or is this pertinent to this model?)

FWS response: This model is an evaluation of a nonnative species and respective invasiveness. Biocontrol is not explicitly addressed or included, nor are these issues expressly excluded. The model is versatile enough to evaluate the invasiveness of species introduced as biocontrols.

91. [There is a] lack of data on a lot of pathogens.

FWS response: The model addresses carriers of pathogens, but not pathogens themselves. Pathogens are defined as a bacterium, virus, or other microorganism that can cause disease. In regard to the lack of data, if we do not have information then the default in the prior probability distribution is uncertainty, or to keep states at equal prior probabilities. The powerful aspect of this model network is that if data are absent, the model allows the use of expert opinion to set the probability states for the input variable nodes. If there are varying opinions on the probability states, the model can be run with differing opinions to assess each respective outcome.

92. Is there a place where a species' susceptibility to predation or competition by resident species is considered? This tells how likely the new species could be injurious.

FWS response: See response to Comment 89.

93. Does habitat suitability include competitiveness? Should establishment be evaluated in part by an invasive species' ability to survive the predation and competition of species already there? This is the biotic component of habitat that is not explicitly represented in the model.

FWS response: Habitat suitability does include competitiveness and this is implied, but not explicit. We address how invasive species influence native species, but not vice versa. Habitat suitability does not explicitly take into account the whole suite of forces that account for species selection. Also see response to Comment 89.

94. Once the modeler shared the outputs of the sensitivity analysis, I see that the most important input node is habitat suitability. After more closely reading the definition of this node, and more importantly, how 'insignificant' and 'significant' levels are defined, I am concerned that it is a bit circular or tautological, in that degree of habitat suitability depends on the likelihood of the species to spread, and produce large amounts of biomass. I'm not surprised then, if species that score high in that variable are most likely to score high in injuriousness. I think it would be better if its rating were based on a more objective habitat matching framework—some degree of habitat similarity between its home (or invasive) range and the U.S. As was explained in the interview, I understood that habitat matching was based on water depth, soil properties, etc. Those characteristics would be better than what I see in the definitions.

FWS response: Habitat suitability is defined as matching habitat. FWS is working on an objective habitat matching approach for river systems (River Risk Assessment Program), but this is not currently available. We will consider including habitat matching if a particular system warrants inclusion. Habitat matching, if incorporated in the future, would inform the Habitat Suitability node. FWS will currently not incorporate habitat matching until the system is completed, evaluated, and reviewed. The Habitat Suitability node in the current Bayesian network model will remain qualitative and on an ordinal scale instead of a scoring system.

95. Habitat disturbance comes in at number 3 (although far behind the previous 2) in the sensitivity analysis. After reading how that variable is defined (the capacity of the nonnative species to cause habitat modification (erosion, siltation, bank stability, eutrophication, sedimentation, etc.) thus causing destruction, degradation, alteration of nutrient pathways, etc. for affected species), I'm concerned that this variable is also tautological in that it includes the likelihood to harm affected species. While defining habitat disturbance in this way may negate concerns that the node is not tied to species effects, it would be better represented by more objective measures of disturbance (degree of erosion, soil disturbance, etc.).

FWS response: No, we do not consider this tautological. Sensitivity may be overemphasized in the reviewer comments. There are other ways to determine how the model is functioning, such as conducting model influence runs by varying the input values.

Also, in the revised model, there is only low sensitivity of invasiveness (the final model outcome node) to habitat disturbance (which is one of the 11 input nodes). Among all 11 input nodes, habitat disturbance now ranks number 6 in terms of sensitivity influence.

Further, although we agree that "more objective measures of disturbance (degree of erosion, soil disturbance, etc.)" would be preferable as a basis for setting the (input) probabilities for habitat disturbance, the reality is that there would likely be few to no data by which to set

such probabilities. The current model structure allows for use of such empirical data if they exist, but also provides for expert judgment of input effects.

96. Where in the model is represented possible effects of bites and toxins on pets, livestock, and other non-wildlife species? The Lacey Act doesn't explicitly address pets, but is this a factor to consider? I believe it was considered with respect to pythons in Florida. In any case, impacts to livestock should be considered in the model.

FWS response: The Lacey Act (18 U.S.C. 42) gives FWS authority to consider factors that are injurious to humans, agriculture (including livestock and aquaculture), and wildlife and wildlife resources. The invasiveness node in the Bayesian network model focuses primarily on those factors that are consistent with FWS's mission and expertise. Harm that may befall agriculture would be largely deferred to the Department of Agriculture (USDA) under their respective authorities. However, FWS can still consider these factors when making its injurious wildlife determination outside of the Bayesian network model during rule promulgation. This model may be modified in the future to better accommodate these considerations.

97. Is the "Other Trait" node redundant with species and ecosystem effects? The node definition, viz. "or any other trait that characterizes any form of risk to [insert any appropriate language—e.g., agriculture, horticulture or forestry, and the welfare and survival of wildlife resources]" means any effect other than bites and toxins, on human interests that might also be reflected in other nodes such as species effect. Or, is the intent to potentially double-count the effect of an invasive species?

FWS response: No, the Other Trait node is not redundant with other nodes. The Other Trait node clearly goes to the Human Effect node and not the Species Effect or Ecosystem Effect nodes. The Other Trait node considers traits that have a direct influence on humans and have not been considered under other nodes. One example would be the ability of silver carp to leap out of the water when disturbed by boat motors and cause injury to humans.

98. Aside from, or prior to, establishment, is initial introduction— especially frequency of introduction—a factor to consider in this model? It stands to reason that a species that is more likely to be introduced repeatedly (e.g., it is likely to be imported repeatedly or in large numbers) is likely to have multiple opportunities for escape.

FWS response: This model presumes that invasiveness is uncertain (from the Ecological Risk Screening Summary model) but that initial introduction has or can potentially occur. With this clarification, no model modification is needed. The Transport node accounts for the frequency of introduction.

99. [I] am concerned that the model behaves so as to give too low a score for a species that can be harmful to people (e.g., bites or venom) even if the species has low potential for establishment and spread. E.g., consider a venomous snake first coming into port where an inspector would put their hand into a crate and get bitten. Based on background information provided by USFWS, that characteristic has been sufficient in the past to justify injurious status. Since one of the drivers for the model is to assist FWS in the face of sparse human resources devoted to assessing injuriousness, it is important the model effectively replicate the factors (and their respective importance) that a skilled analyst would consider.

FWS response: The model has been modified to include the third state “Evaluate Further” in the final output, to account for the situation where a species has a low potential for establishment and spread, but can cause significant harm.

100. I consider ecosystems as comprised of species. I suggest that you consider how habitat disturbance could affect individual species and not only the structure, function and composition of ecosystems. For example, some species are highly impacted by destruction of nesting sites that results from habitat disturbance. Is that any less important than competition and predation on the health of that species? Therefore, I suggest that you link habitat disturbance also to species effect.

FWS response: Species is in the definition as part of the Ecosystem Effect node and other parts of the model already explicitly account for species-specific effects. No modification of the model is indicated.

101. Consider the potential for accounting for ‘ecological release’ where an invasive species would escape its native competitors and predators when introduced into the U.S. Can we find such examples and use them to test and update the model? This is an example for which knowing the species’ susceptibility to predation or competition in its home range would help determine how it may behave in the absence of such influences in a new environment. So, a species that is “kept in check” by a specific predator or parasitoid, etc. in its home range may be likely to take off when that predator is absent. Adjusting the model to include those cases would be very helpful.

FWS response: At this time, the model does not include that level of complexity. No databases exist that would allow us to test the model and finding examples would require a great deal of time and effort. We believe this level of refinement may be necessary for further risk screening occurring under the “Evaluate Further” outcome of the invasiveness node of the model.

102. I worry about the Human Transport node; it is different from the other inputs in that it’s about human behavior not species attributes, and thus could be changed (managed) or may change independent of management. One assumes that a species is being evaluated based on the characteristics of the species, not human management or human behavior. Thus, if human transport had much influence, one could interpret injuriousness [invasiveness] differently. In comparison, all the other inputs are independent from, or indirectly a function of, human activity.

FWS response: Human transport is included because most invasive species are introduced into new habitats because it has been transported by humans. Thus if human behavior was modified through risk management actions, this could alter the invasiveness outcome for a species. We intentionally constructed the model to consider both human and non-human dispersal methods. We consider this a strength of the model and that this node is appropriate.

103. The model structure doesn’t adhere to the literature’s probabilities of establishment and spread. An alternative could be to devise the model as a series of conditional probabilities, but the Bayesian network (BN) model indirectly captures that plus it allows species to be injurious without being invasive, e.g., with poisonous snakes that are not established but that could still pose a threat to human health.

FWS response: No response required since the comment suggests that the Bayesian network model structure is appropriate. The model assumes introduction and then evaluates the effect of establishment, spread, and impact.

104. Given the comment in Marcot et al. 2006 that “the sensitivity of the output node to input nodes may be swamped and dampened by intermediate nodes”, it is worth considering whether the structure of the model inherently makes the outcome more sensitive to Climate and Habitat Suitability (which are 2 nodes away from injuriousness) than to other input variables (which are all 3 or 4 nodes away). In the brief testing of sensitivity that we did online, I was surprised at the sensitivity results (although also acknowledge that I may have been expecting the results to tell me about influence, rather than sensitivity).

FWS response: The citation included in the comment is true that intermediate nodes introduce uncertainty by spreading conditional probability values among outcomes such that uncertainty tends to propagate through a sequence of intermediate nodes to the final node with all else being equal. However, the intermediate nodes in the current model are mostly designed to simplify the probability table sizes and not to swap any signal by introducing excessive uncertainties. Further, the sensitivity structure tells something different about the model than the influence of operating inputs. Invasiveness (formerly “injuriousness”) is affected by establishment, spread, and harm in ways that allow the effects of the inputs to be felt as intended regardless of the number of intermediate nodes. The effect of the intermediate nodes is not dampening the effect of climate and habitat, and thus, the model is behaving appropriately.

105. The variables are right for the harm side, and cover most of the harms related to invasive species. Trophic effect may be more like a parent (input) node than a child node in the model, as it might cover effects other than predation, competition, etc.; one example is zebra mussel which causes benthification of productivity.

FWS response: The Habitat Disturbance and Ecosystem Effect node definitions should be expanded to include trophic effect, and we have revised these definitions.

106. I was surprised to not see a relation between ecosystem effect and species effect. Perhaps elevate ecosystem effect to parent (input) node status; or, alternatively, species effect could be the child of both species and ecosystem effect.

FWS response: A node cannot cycle back to itself. Thus, the Species Effect node cannot be a daughter node of Species Effect. Both Ecosystem Effect and Species Effect are included in the conditional probability table under harm, and thus both are considered in relation to one another. Ecosystem Effect and Species Effect are influenced by common inputs (predation, competition).

107. Use of uniform probability distributions for the prior probabilities (for the input nodes) is not defensible. Instead, rely on, or conduct, some literature reviews or meta-analyses; a more defensible prior probability distribution might be one that has a smaller proportion of the significant state.

(We tested using priors as 45-45-10% in all inputs for the states None, Insignificant, and Significant, respectively. This had the effect of lowering the probability of injuriousness under conditions of full uncertainty, which is more consistent with the literature and with my intuition.)

FWS response: This change to prior probabilities (as noted in the parenthetical comment above) can be made, presuming that appropriate rationale and meta-analysis of empirical data can be provided. However, at this time, we can find no foundation (literature or data) by which to empirically adjust the prior probabilities from uniform distributions. If needed later, species can be reanalyzed using alternative values of prior probabilities if and when data become available by which to change the priors from uniform distributions.

Changing prior probabilities can indeed affect the outcome. We ran the model using (1) uniform probability distributions for all input nodes (33-33-33% across the three states for all input nodes), and also using (2) 45-45-10% and (3) 50-25-25% values. The resulting models differed, as would be expected, in the posterior probability outcomes of Invasiveness, both when running the model with all default priors and when running the model against a known species outcome (Northern snakehead), although qualitatively the three models did not differ in dominant outcome probabilities when parameterize for a given species. Running the uniform-distribution model for Northern Snakehead produced a dominant probability outcome of 92.2% “Yes” for Invasiveness; running the 45-45-10% priors model produced a dominant probability outcome of 84.5% “Yes” for Invasiveness; and running the 50-25-25% priors model produced a dominant probability outcome of 92.2% “Yes” for Invasiveness, same as with the uniform probability model. The sensitivity structure of these three model variants also were quite similar, with input variables having the same rank order of sensitivity effect on Invasiveness outcomes, although specific sensitivity values slightly differed for each input variable among the three model variants tested here. (Test results are available upon request.)

It should be remembered that when values for the input variables (nodes) are specified, such specification effectively overrides the prior probabilities set for each input node. It is a pertinent issue, however, when no information is available by which to set the input nodes, in which case the analysis reverts to using the prior probability values for those nodes. In some cases, also, model variants without uniform prior probability distributions will slightly alter some input values due to internal calculations for model consistency. This may be appropriate for some modeling objectives, but is not appropriate for the intended use of this model as a decision-aiding tool.

Thus, for the reasons given above, we have retained priori probabilities as uniform distributions for all input nodes in the model.

108. In cases where no prior information exists about a particular input node, it makes sense to use a default of uniform probabilities for the unconditional prior probability tables of the input nodes (the blue nodes in the model diagram). However, there are two ways that one could think about a uniform prior—as has been done in the current model version, one option is to give equal weight to “no effect”, “insignificant effect” and “significant effect”. But this could also imply that there is twice the weight for no effect (how I interpret the two states of “none” and “insignificant”) than on an effect (the state “significant”). How different are the results when total uncertainty is represented by inputs set to 25, 25, and 50% instead of uniform probabilities, for the 3 states (none, insignificant, and significant) respectively?

FWS response: See response to Comment 107.

109. When uniform priors are used, the injuriousness outcome tends toward 50% (not exactly, but close). This is intuitive in a way, because it would be difficult to tell if a species was going to be injurious or not if there was no information about that species. On the other hand, invasion biologists tend to agree that well less than 50% of non-native species could cause harm, so uniform priors might overstate the potential for injuriousness in the face of total uncertainty.

FWS response: See response to Comment 107. With the revised model having an additional third state “Evaluate further” in the Invasiveness outcome node, this outcome changes; with deterministic outcomes in the conditional probability table (CPT), the default outcome now tilts more toward “Evaluate Further” with total uncertainty of all inputs with priors set to uniform probability distributions. We will explore resetting the CPT in the outcome node to a probability basis instead of deterministic outcomes.

110. Species effect should be more sensitive to predation and competition than to pathogens and genetics, based on its definition and as demonstrated with sensitivity analysis.

FWS response: The influence of the Genetics and Pathogens nodes were not intended to be equal with that of the Predation and Competition nodes. Effects from genetics and pathogens can be permanent, whereas, effects from competition and predation may be altered or reversed.

111. Genetics will mostly be “none” due to lack of congeners in North America. There may be genetic effects other than introgression and hybridization to consider. For example, another potential genetic effect could be the presence of the invasive species leading to genetic drift in the native species because of behavioral modification.

FWS response: There may be congeners in North America. Our definitions says “through direct genetic influences,” and as such we are only focusing on direct effects mainly because indirect effects are difficult to predict. It is our intent for the model to focus on direct effects as stated in the definition.

112. If the climate 6 score is high, and habitat suitability is unknown (with its default, prior uniform probability distribution), and harm is uncertain, the model leans toward not being injurious, but this isn’t consistent with the precautionary principle.

FWS response: When harm is uncertain, we do lean toward not being invasive (injurious) in concordance with our authority. Additionally, we specifically did not design the model to tilt toward a specific outcome in the presence of substantial uncertainty; this is the purview of risk management, not risk analysis.

113. Comments are provided above regarding elevating the ecosystem effect node to parent (input) node status.

FWS response: See response to Comment 106.

Questions or comments on model operation, and suggestions for further testing the model

114. You want to test the model with species that would be output from the rapid screening system as uncertain (the current test was done on species known to be invasive or known to not be invasive—they would not have been viewed as ‘uncertain’ using the current screening method). The challenge with doing so is that because these species are uncertain, we don’t have

a ‘gold standard’ test (e.g., real life experience, which is what was used with the 50 species tested). Still, the rankings themselves can lead to research priorities on such uncertain outcome species, the results of which can then be used to test and update the Bayes net model.

Also consider species with data from other countries, not a U.S. centric perspective, by which to test and update the model.

FWS response: It is not logically possible to “test” the model with species deemed to be “uncertain,” assuming that “test the model” refers to determining if the model would predict known outcomes. The model can certainly be “run” with species deemed to be uncertain, but this is not a test of prediction accuracy of the model. The comment that the rankings (probabilities of injurious) can lead to research priorities is partially true. FWS may also want to know what led to those probability outcomes and the value of additional information on uncertain inputs that have greater influence on the outcome probability values. This can be determined not by “testing” the model with uncertain species, but by evaluating the extent of data available on a given species as used in the model.

Testing and potentially updating the model with additional data on species from other countries is a very good idea, but again, prediction testing can be accomplished only if the true outcome is known. We tested some species (such as Prussian carp, stone moroko, Wels catfish, Nile perch, and roach) that are known to be invasive in other countries. These species have a history of invasiveness and harm in other countries, but have not yet become established in U.S. ecosystems.

115. How can the model be tested and updated with gray-zone [uncertain injuriousness] species? Can we use information from their native habitats and ranges to predict injuriousness? That is, determine what we would have scored a species before its subsequent, known outcome, and test the model with that information. This kind of test would be most appropriate because it most closely mimics the situations for which the model is intended to be used. This comment ties in with [another comment of mine].

FWS response: This was addressed partially above, in Comment 114. It is unclear how to “score a species” before its outcome is known. Also, it would be tautological to initially predict some outcome based on the same information used in the model, and then use the model to demonstrate that outcome. The model can be further tested not necessarily for accuracy of predicting invasiveness when that outcome is ultimately unknown (unlike our set of 50 species with known invasive outcomes), but instead for consistency and credibility in how segments of the model perform such as denoting ecosystem, species, and human effects and harm, establishment, and spread. As we develop initial data sets on species to evaluate, such tests for consistency and credibility can be completed.

116a. Along the lines of the earlier comments on how best to test the model: I suggest that the developers take a species that, based on the rapid screening method, is now classified as having an uncertain level of injuriousness. Then, gather and evaluate data in the usual way that the staff would typically do for determining its injuriousness. Have another person run the model (blinded of the results of the first analyst). Is the result the same? Perform this test on several species in the uncertain category as a means of testing against your current ‘gold standard’ of manual analysis. This approach can potentially lead to the calculation of a sensitivity and specificity for the model.

FWS response: We have revised the model definitions and are preparing a User's Guide that will include a set of standard operating procedures and guidelines for interpreting data on a species in terms of the Bayesian network model node states.

116b. One thing to keep in mind is that the model produces a percentage likelihood score for injuriousness. Tests of sensitivity and specificity use binary criteria (positive/negative). Therefore, the modelers must determine what cut-off score would be considered positive or negative for injuriousness. If the modelers would prefer to maintain the likelihood score for injuriousness (which has real relevance since in reality, a species is not likely to be equally injurious in all situations), then their manual results should be expressed in comparable terms as to make a direct comparison possible. If the model doesn't provide a reliable recreation of the manual process – why? The developers should adjust the model to better reflect the current evaluation process, OR should decide if factors currently being considered in the manual approach should not be. This approach can also be used to test potential edits to the structure of the model, including those that I have suggested here. The best structure is the one that can reliably produce meaningful and useful results, regardless of the opinions of reviewers such as myself.

FWS response: The review is correct in characterizing sensitivity and specificity of model results and metrics of prediction accuracy. For testing the model thus far with the test dataset of 50 known-outcome species, the cutoff value of invasiveness probability for evaluating model prediction accuracy was 50%. However, this is not necessarily the same probability threshold that a decision-maker might use in determining listing actions for a given species, but it is useful for model testing.

The testing that has been done on the model using the 50 known-outcome species has already included: (1) using that dataset to temporarily readjust the prior probability values of the input variables, (2) testing the prediction accuracy of the alpha-level (pre-peer review) model (it predicted correctly 100% of all cases using the 50% cutoff threshold), and (3) updating (slightly adjusting) the conditional probability tables in the model to even better adhere to the 50 known-outcome species. All this means that we have produced the best possible model structure to date, as the reviewer suggests.

117. Why not use existing approaches, such as FISK?

FWS response: The Bayesian network model approach provides for sequentially improving model structure and performance by incorporating new information on known-outcome species and other data, and provides the outcome in a flexible probability-based presentation that can be amenable to informing listing and other risk-management decisions. It also provides an intuitive depiction of how variables combine to result in outcome scoring of invasiveness and a rapid and repeatable means of determining the relative influence of uncertainty and of individual controllable factors affecting the invasiveness outcome. Among other reasons, these characteristics are why the Bayesian network model approach was selected.

Further, comparison of various tools (external to FWS) is ongoing by an independent group. It may be useful later to do a model comparison (what variables do the Bayesian network model and FISK approaches have in common or not, and why), and to run some test cases of species (with known or unknown outcomes) using the Bayesian network model and other approaches, if possible, and compare results. We can support use in some cases of FISK runs or

results from other risk assessment tools in the Bayesian network or as complementary to outputs from the Bayesian network, in the spirit of multi-model approaches to “Invasiveness” evaluations. The agency recently entered into an invasive species “voluntary risk management” MOU with the Association of Fish and Wildlife Agencies, Pet Industry Joint Advisory Committee, and others where the agency’s role is providing the results of risk screening to the parties. The MOU acknowledges and welcomes parties bringing forward the results of their risk screening and risk assessment approaches as well.

118. One of the steps proposed in the development of this model is to update the CPTs from the alpha model (based strictly on expert opinion) to a beta model that improves the fit to a set of fishes with known injuriousness. I am hesitant about the value of moving from the alpha to beta model until I know better whether the beta model is robust regardless of which species are used to make this improved fit. As I understand the beta version of the model, it was developed based on 50 fish species (25 species of which are known to be injurious, and 25 species known to be not injurious). Thus, the new CPTs are no longer independent of the data that are being used to both develop and test the model. I would recommend finding another set of 50 known-outcome species (perhaps from those available through Garcia-Berthou 2007, see below) and going through the same alpha-to-beta process. If the CPTs change in the same way regardless of which set of species is used to update the CPTs, then that is great. If not, then I am not really convinced that the beta version is any better than the alpha version. The test cases may be best used as a way to test the model and not necessarily update it.

FWS response: The basis for this comment is partially incorrect; the beta model was an adjustment of the alpha model using the 50 test species with known outcomes, yes, but the species dataset was used to adjust the conditional probability values already in the alpha model (as set by expert judgment). That is, we retained the original probability structure of the alpha model, on top of which we included the 50 species cases. The beta model was *not* based *only* on the 50 species; this would have not been a correct approach, as it would likely overfit the model to only that set of 50 species, which is likely the concern of this reviewer’s comment here.

That said, it is a good point that when the model was retested after incorporating the data from the 50 known-outcome species test set, it was indeed tested to see how well the model had been adjusted to that data set. If we had a test database of at least several hundred species with known outcomes of invasiveness, we could have run a cross-validation (jackknife, or k-fold cross-validation) approach to update the model with one set of data and test it against another. We did not have that database available, and developing it would have taken an inordinate amount of time, so we opted for the current approach and intend to be able to further improve and update the model as new information becomes available.

In general, we argue that using test cases and new information to sequentially update the model is appropriate and, in fact, desirable, in the spirit of “empirical, sequential Bayesian modeling,” e.g., as used in Gazey et al. 1986 and Link and Sauer 1996.

119. The team may find the model structure and even CPTs applicable to taxa outside of freshwater fishes. Freshwater mollusks and crustaceans and marine species would be obvious first candidates for expansion of the model’s applicability.

FWS response: We agree. The model, however, is intended to be used first with freshwater fishes, and will be clarified as such. The model may work well with other taxa, or may need amendment, and will be determined later.

120. I agree with the approach and the process in setting up the CPT values. You might also establish them with additional experts from a broader range of backgrounds in academia, government agencies, NGOs, etc.

FWS response: We agree that probability values in such models can gain further reliability or credibility when developed with multiple expert input. There are tradeoffs to such approaches, however, such as the time, cost, and complexity of convening expert panels, or working with experts individually and sequentially, and also the considerations for how to combine and interpret additional experts' judgments and suggestions. The model was developed in a team setting internal to FWS, but for that reason and others, was then subject to five individual, independent peer reviews from subject matter experts outside FWS, who were given full opportunity to explore and comment on all CPT values in the model. We decided to move forward with the model as constructed, tested, and amended from these reviews. Further, we advanced the current model as a decision-*aiding* tool, not as a definitive ecological prediction tool. That is, we encourage that results from the model be evaluated further and not necessarily taken at face value, particularly if there is concern about information, uncertainty, or results of a given species.

121. I thought some about whether there were cases that would be additional tests of the utility of the model (that is, additional to the 50 fish species of known injuriousness/ non-injuriousness). In conversation while looking at the model, I suggested comparing the BN model to a model that included more continuous, quantitative input variables. Upon reflection, I think that better model tests are to find additional fish species of known injuriousness status and examine how well the model performs in prediction. This means that species-specific demographic information does not get used at all in the model, and interaction strengths (i.e., predator and competitor effects) get abstracted from some per-capita or population-level effect to a simple ordinal score.

FWS response: We agree that it may be useful and instructive to further test (and also update) the model with additional, known-outcome species, and may pursue this effort as time and funding permit. For now, however, we are satisfied that the 100% accurate predictions of the model made on the 50 species of known outcomes provide a basis for the next phase in model application.

122. It seems like a good idea to use a combination of influence and uncertainty to prioritize factors for which additional study or data collection may be warranted.

FWS response: Comment only, no response required. This is indeed a function of the model that we or others can pursue for additional study on selected species and circumstances to help clarify implications of knowledge and uncertainty.

123. The probability of injuriousness alone is not going to be very useful without knowing what contributed to that score for a given species. E.g., for a species with a low probability of establishment but a high probability of harm, you want to be cautious about restricting it.

FWS response: This is one of the main reasons why we used the modeling framework that we did: it provides an explicit, intuitive network structure that can clearly display the implications and influences of each variable on each species, and that can be easily further tested to determine the potential role that uncertainty plays in the predicted outcomes of invasiveness probabilities.

This was also the reason we changed our outcome node from “injuriousness” to “invasiveness” to acknowledge that any injurious determination (with accompanying prohibitions) require other administrative and decision-making processes.

124. The current model is for freshwater fishes; it would be interesting to apply the model to other freshwater groups such as mollusks and crustaceans, and perhaps also marine species. The broader issue is a caution against using this model with other taxa for which it was not designed, without first testing it.

FWS response: Very good point, and is addressed in Comment 119 above.

125. Having an additional set of known-outcome species to test the model would be useful, if the test species were not necessarily as saliently injurious or not. It is possible to identify such additional test case species. These would be species closer to the midpoint of the scale of injuriousness but still on one side or the other of the threshold.

This is particularly important, given the purpose of the model to be used on species with an ERSS unclear outcome result.

FWS response: We agree, and it is a very good point to test the model against species for which their outcomes are not so clearly invasive or not invasive, if their true outcomes were also known. If, and, as time and funding allows, we may pursue this approach, which we address in Comment 121 above.

126. There is a large literature on evaluation of freshwater fishes; it would be great to compare the model against some of those assessments using the same data inputs. These models and data sets are reviewed by Garcia-Berthou (2007). Given that other modeling approaches do not necessarily predict “injuriousness”, but rather address factors predicting establishment, for some comparisons it may be necessary to force the “Harm” node to uniform probabilities and then use this literature to define the values of the inputs to establishment and spread.

FWS response: This is a very good idea; our response to suggestions for further model testing are as per Comments 119 and 121 above. But, in general, this is a good idea for testing segments of the model independently, which would be an appropriate approach for a Bayesian network model. If and as funding allows, we may pursue this approach.

127. It would be a good idea to test various model structures for different taxa other than freshwater aquatic taxa (fish).

FWS response: See response to Comment 119.

128. [Regarding “uncertain” risk outcomes:] I advise clarifying what circumstances would lead to an uncertain outcome. This process is important, as it determines the universe of species that would be subject to the Bayesian network model.

FWS response: This pertains to the operation and result of the Ecological Risk Screening Summary (ERSS) model, and is a very good point that needs to be clarified in any User's Guide or description of the Bayesian network model. We will make this clarification in model documentation.

129. [Regarding calculating sensitivity of outcomes:] I wish that we had more time to go over exactly how this is done. After I submit my initial comments, it may be worth doing that.

FWS response: We remain available for further help and interaction on this point.

130. I like the fact that the model is Bayesian and can therefore be updated with new information. I would like to see how it can be used 'looking backward' to see how we can better recognize potentially invasive species before they are known to be, by comparing current estimates with those that would be generated using older information. This notion ties in with [another of my comments, above].

FWS response: Perhaps this point pertains to some form of "hindcasting" using incomplete or early data on a species, determining its invasiveness from the model, then incorporating later data on the species and again projecting invasiveness? It is not entirely clear, however, how to determine "older information" for the hindcast projections. If we discover such information, we may attempt this further model testing.

Suggestions for protocols for developing and documenting species input data when running the model

131. Due to significant data gaps, especially as relates to "invasiveness," for most species, the process allows for significant intuitive conclusions that more often than not rely on subjectivity or best guestimates of the person(s) inputting data into the tables for determining input variables. While "prior knowledge" is critical in construction of the input table, a number of safeguards need to be formalized in the process to minimize speculation, bias, etc.

FWS response: We are preparing a User's Guide that will aid the assessor in completing the input table (template spreadsheet). All information informing nodes will be put into the table with all references. If published literature is used, copies of all papers and documents will be saved as part of the Administrative Record. There will likely be a small learning curve when we start assessing unknown risk species.

132. Development of the priors needs to be documented with some degree of detail not only for transparency, but also to minimize predetermining the outcome or inadvertent omissions. See also points on ensuring (1) assessors or reviewers and ultimate regulators are not one in the same, (2) that expert derived data developed and recorded in sufficient detail to have a complete administrative record.

FWS response: We agree, and will devise the model User's Guide accordingly. All information used to inform nodes and accompanying references will be recorded in complete detail in the Administrative Record.

133. The biggest need is to document every step when identifying input values for species. Need transparency, especially if dependent on literature. The input table does not reveal sufficient information to have a detailed administrative record, nor sufficient data for real

transparency. While I recognize that the sample table was not fully documented, future instructional examples for assessors should include a more fully documented sample to illustrate the depth of information needed.

FWS response: See response to Comments 131 and 132.

134. There should be some criteria for the makeup of the subject expert or panel that identifies values of the inputs for given species. For example, an ecologist is needed to address ecosystem effects, climate change, etc.

FWS response: FWS biologists will be interpreting data and assigning values for each of the nodes. While there is merit to having separate subject matter experts, there is also merit to having a few skilled staff biologists trained in the procedure to provide consistency and to minimize the time involved in producing the outcome. We also believe this may be more consistent with the personnel and fiscal realities of the agency.

135. The composition of subject matter experts is critical for ensuring objectivity, credibility, and, needless to say expertise. As noted below, the protocol needs to clearly provide that the assessors and ultimate regulators should not be one and the same.

Additionally, as noted by the National Academy of Sciences in a number of papers on risk assessments, stakeholder involvement is an important element and should be included in the process whenever possible. Stakeholder participation in the process is an important factor that should not be ignored. Recognizing that stakeholder inclusion is unfortunately problematic within a Federal setting, such interaction should be required when the process is utilized by non-Federal entities, especially states or non-governmental organizations. Such inclusion increases transparency, provides access to information or data normally not readily available to government assessors and, hopefully, mitigates or minimizes bias.

FWS response: As for subject matter experts, see responses to Comments 131-134. The role of stakeholders will likely occur during the risk management phase and not necessarily in the risk assessment phase (of collecting data on species and initially running it through the model). We recognized the value of stakeholders in the process and thus include a representative in the peer review process. One benefit of using the Bayesian network model is that the assessment scores are saved and can be made available to the public and subject matter experts for review, thus allowing for transparency. What is important to understand is that the model's result is not the final answer for whether a species should be listed as injurious. Rather, the Bayesian network model is used when the ERSS process results in "uncertain" risk. Once a species is run through the Bayesian network model using scientific information, and depending on the resulting score, FWS will then decide whether to pursue listing the species and will have to justify the listing in the rule, at which time there will be an opportunity for stakeholder input.

The Fish and Aquatic Conservation Program generally differentiates between risk assessment and risk management roles in carrying out the agency's responsibilities under the injurious wildlife provisions of the Lacey Act; however, we can't unequivocally commit to this approach in this responsiveness summary binding the agency's hands in the future. Rather, we will balance the fiscal and staffing realities of the agency in delivering its conservation mission with the benefit of keeping these roles differentiated.

136. As noted by the USFWS in its constrictor listing a “factor strongly associated with establishment success is having a good climate and habitat match between where the species naturally occurs and where it is introduced.” Thus, incumbent on assessors constructing the input table need to carefully review and document resources relied upon in determining the significance of the match. This area is one of the most challenged aspects of risk assessments, especially as to aquatic species. [This reviewer] questions whether or not [it is] important to include specific instructions for assessors.

FWS response: We are preparing a User’s Guide for this model.

137. There may be a risk of going from “what if” to “as if.” Goes back to the credibility of the scoring for each species to be analyzed by the model. The values of inputs have to be vetted through QC/QA.

FWS response: See response to Comment 131.

138. How much time would it take to fill out inputs for a given species? This gets back to the credibility of setting up an “input value table” (such as FWS’s hot and cold list species spreadsheet) and to need to document the rationale and references. [You] need to add in comments to document source material. The biggest issue is transparency for data relied upon. Call it source information. Clarify any uncertainties.

FWS response: This model is intended to save FWS time when assessing species. See response to Comment 131.

139. While it may be inferred that basic tenets of the National Academy of Sciences’ recommendations for risk assessments are incorporated in the process, I recommend that the protocol specifically note that the assessors and reviewers are independent and not the ultimate regulators responsible for evaluating the results for the purposes of rule-making, legislation or developing mitigation measures. This is important for both transparency as well as for scientific credibility and objectivity.

FWS response: We will include this recommendation in the User’s Guide.

140. One should not ignore Jim Quinn’s (UC Davis) admonition on simply relying upon database summaries rather than underlying references due to “garbage in – gospel out.” A checklist would reduce the likelihood of human nature (error) resorting to relying on summaries in lieu of thoroughly checking references. In the event FWS incorporates a QA/QC mechanism as a safety net, the instructions should specifically explain the importance of and the need to utilize and comply with the QA/QC checklist(s). Even more important when assessors resort to roundtable group sessions to reach a consensus. In such circumstances, must document what was relied on in reaching consensus if the process is to be credible and science-based rather than one person dominating the direction. Otherwise, not sure how one tests sensitivity and bias.

FWS response: See response to Comment 131. We do not intend to have a roundtable group discussion to reach a consensus for any species. When we first begin this process, we may have several people assess the same species and then compare results to address the consequences of speculation and bias on the outcome of the compared assessments. We will also include in the User’s Guide the recommendation that assessors include reference primary literature on a species.

141. In the Other Trait node, would the non-permanent impact such as from jumping carp be appropriately graded as insignificant? To what extent does risk perception play a role in the weighting of injuriousness? The implication is, would a species be considered to be listed because it is a public nuisance issue even if it is not otherwise very injurious? If the answer is yes, then the weight of the states should reflect that.

FWS response: If a species caused significant harm to either humans (zoonotic pathogens) or other animals but did not establish or spread, it may have a low potential for invasiveness. FWS may still decide to list such a species as injurious if it meets the Injurious Wildlife Evaluation Criteria authorized under the Lacey Act (18 U.S.C. 42).

142. Reliance on an “input team” is of concern. The ERSS process is not clear as to whether or not individual assessments would be merged into a chart when input from multiple assessors or would multiple assessors participate in a group session to discuss and record the “group consensus?” I recommend that the protocol should be abundantly clear as to be how multiple assessments are merged into the final chart. Personally, and based on recent experience with a faulty process utilized by NOAA/NMFS, “group think” or “group therapy” sessions are undesirable since the knowledge level of the participants varies significantly and undue influence could result from a particularly vocal member who may or may not possess the requisite expertise. To avoid bias or lack of objectivity, I strongly recommend that, whenever possible, that development of documented priors be conducted by one or more people individually with their analysis combined for or by the reviewer. Group dynamics should be avoided whenever possible.

FWS response: The ERSS process is prior to, and separate from, use of the Bayesian network model, and is not addressed here (nor in the model peer reviews). It is not anticipated that an “input team” will be used to apply the Bayesian network model. See response to Comment 140. That said, we are very much aware of the potential problems associated with use of teams or expert panels; in a separate project, one of us on the Bayesian network model development team (B.G. Marcot) developed, implemented, and published a strict protocol for avoiding such problems (Marcot et al. 2012).

143. While I recognize that the “input chart” utilized in the Webinar hopefully does not reflect quality of “comments” accompanying the Bayesian Network Score, the process needs to clearly require assessors to insert in the “Comment” section not only what base decision on, but also include citations justifying their conclusion. The assessor should also record (1) databases searched and (2) resources checked but not relied upon. Otherwise, there is no credible way to ascertain thoroughness of their assessment. Such information critical for administrative record as well as for transparency. [I] cannot overemphasize importance of such information, especially when there is no stakeholder involvement.

FWS response: See response to Comment 131.

144. Consider redesigning input table to include a “References” box below the “Comments” box. The Reference box would be used for full citations to resource materials including databases. Also, when completing the comments, they should indicate references/resources.

FWS response: We will add a References box to future input tables. All comments must be accompanied by references.

145. What steps are taken to minimize bias? What if there is a disparate group of responses among the experts by an input team? See comments above.

FWS response: See response to Comments 131 and 142.

146. Inclusion of a Quality Assurance/Quality Control mechanism at both the assessors and reviewers levels to aid/ensure transparency and objectivity. This is critically important at the initial stages where an expert or experts provide priors in the “input chart.” A QA/QC checklist is essential to ensure that (a) the best available science has been reviewed and relied upon and properly referenced and documented, (b) an adequate selection of resource databases have been reviewed, (c) there is inclusion of a well-documented administrative record, and (d) transparency is strictly adhered to at each stage of the process. I recommend inclusion of a Checklist for each stage of the process to ensure that the assessor/reviewer has in fact performed the requested task(s). The Checklist should include a comment area wherein the person indicates any anomalies identified or deviations from the prescribed steps. This would allow the transparency needed to ascertain objectivity of the process. Inclusion of a rigorous QA/QC mechanism would enhance the process’s usage of the best available science and strengthen its scientific foundation.

FWS response: We will include a checklist with the User’s Guide. See also response to Comment 131.

The following comments are from the Definition Document.

- A. Is ISRAM to apply to potential invaders not yet in U.S. or not yet documented as established or only for those species after establishment? I would also insert definition up front that states that a native species includes species within federal trust areas or better way to describe within the United States, any territory of the United States, the District of Columbia, the Commonwealth of the Puerto Rico, or any possession of the United States. See Lacey Act, 18 USC 42(a)(1).

FWS response: ISRAM (Bayesian network model) was intended to apply to any fish species that comes out as uncertain risk from ERSS and may include species that are already established in the U.S., in trade, or not even here. While this is its intended use by the FWS, we believe results are applicable for species with known risks as well. ISRAM applies to potential invaders not yet in the U.S.; we believe the model will help the FWS become more proactive (than reactive) with its risk management actions for invasive species that are not yet established in the U.S. We have added a definition for native species.

- B. Is nonnative a species not native to US or species outside its ecosystem?

FWS response: We can assess species that are not native to the United States or outside of its native ecosystem within the United States.

- C. Unfortunately, USFWS has not published listing criteria as stand-alone document.

FWS response: FWS’s Injurious Wildlife Evaluation Criteria are published in the Final Rule listing for Three Python Species and One Anaconda Species as

Injurious Reptiles ([77 FR 3330](#); January 23, 2012). Commenter inserted these criteria under the Habitat Disturbance Comments and Citations section but we feel that it is not appropriate and have removed this addition. These are the current listing criteria.

- D. What constitutes “substantially”—plus 50%? I would instruct assessors to document what they consider substantial and assign a percent on input chart. Based on documented evidence, they should assess degree of substantial impact.

FWS response: We have provided examples to better illustrate the definitions. We have not set percentage thresholds.

- E. [I] would delete references to Trust species since Lacey does not use that language.

FWS response: See response to Comment 68.

- F. Regarding Disease (now Pathogens) definition -- Illustrates why assessors inputting data into input chart must document sources since we have witnessed FWS misinterpreting data in these areas.

FWS response: We will be documenting all information and sources into the template spreadsheet and Administrative Record.

- G. Regarding Bite & Toxins definition—To best of my recollection this not used to date to list species under Lacey and is very controversial issue with many veterinarians, trade, etc.

FWS response: We believe that this is a valid consideration for determining whether a species causes harm.

- H. Regarding Other Trait definition—ZOOZOSES APPLIES ANIMAL TO HUMAN; I would also insert diseases that impact other animals.

FWS response: This node helps inform the Human Effect node and therefore, zoonoses infecting humans should only be included. Pathogens that affect other animals are included under the Pathogens node informing the Species Effect node.

- I. Regarding Other Trait definition—Technically, most if not all snakes constrict.

FWS response: We removed “Constriction” from the Comments and Citations section.

- J. Regarding Other Trait definition—What about nonnatives hybridizing with native species?

FWS response: Hybridizing should not be included as an example. Hybridizing with native or nonnative species is included in the Genetics node.

- K. Regarding Human Transport definition—Normal “Lacey speak” is “intentional and unintentional.”

FWS response: We have revised the definition to reflect intentional and unintentional introductions.

- L. Regarding Human Transport definition—Does this mean “introduced into the environment” or introduced into a state though in confinement not released or escaped into the wild?

FWS response: We have revised the definition to read “Any assistance (whether intentional or unintentional) by humans for moving the subject species from one location to another and introducing the species into an environment beyond a range where they were established and can move from on their own.”

- M. Regarding Climatch definition—Does this mean “introduced into the environment” or introduced into a state though in confinement not released or escaped into the wild?

FWS response: CLIMATCH refers only to the match of climate for source locations (that is, native and established range) with that of target locations (that is, typically the contiguous U.S.). Climate matching is independent of whether the species is in confinement.

- N. Regarding Habitat Suitability definition—[I’m] not sure how to deal with complexity inherent in “habitat” since assessors should evaluate elements to make sure matches similar. For example, [the] need to evaluate air and water temperature, food, altitude, water flow, water quality, etc. [I] am in middle of issue with USFWS on air vs water temperatures since variance can be substantial yet ignored by many in matching habitats.

FWS response: We have edited the definition of the Habitat Suitability node. The Bayesian network model we developed is for freshwater fish species. In a separate effort, we are developing a habitat-matching model for river systems of the world. When that system is completed, we will submit it for peer review and publication. That system will be available for use in the Bayes network model. Regarding air temperatures vs water temperatures, Bomford (2008) used the CLIMATCH system for freshwater fish species. Also, an independent analysis of Climate 6 scores calculated by FWS resulted in a finding that “a model based only on [FWS] climate match performs very well for predefining which species have and have not become established [in the U.S.]” In summary, our climate matching is suitable, based on an independent analysis, for freshwater fish risk assessments in the United States. We look forward to the development and use of habitat matching systems in the future.

- O. Regarding Harm definition—Is “minor” based on percentage impact?

FWS response: See response to Comment 55.

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