U.S. Fish & Wildlife Service

Standard Operating Procedures for the Freshwater Fish Injurious Species Risk Assessment Model (FISRAM)

U.S. Fish and Wildlife Service

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Part One: Background

Invasive species cost the United States billions of dollars annually in losses and damages, including loss of crops and fisheries, damage to utility operations and water supplies, and risk to human health from zoonoses (Pimentel et al. 2005). Prevention is the most effective, least costly way to reduce or eliminate the effects of invasive species (Leung et al. 2002; Keller et al. 2008). Risk assessments to identify potentially invasive species can help anticipate problems and focus limited resources for management. Natural resource management aimed at preventing invasive species introductions and minimizing new invasive species incursions is critical to reduce the negative effects of species' invasions to the United States' valuable resources.

The U.S. Fish and Wildlife Service ("Service") has the authority to list wildlife (wild mammals, wild birds, fish, reptiles, amphibians, mollusks, and crustaceans) as injurious under Title 18 of the Lacey Act (18 U.S.C. 42) through the Federal rule-making process. Under this statute, injurious species are designated as species that may cause harm to the interests of human health or welfare; agriculture, horticulture, or forestry; or wildlife or wildlife resources of the United States. The statute gives no further description or definition for injurious species. Federal law prohibits importation of animal species listed as injurious by the Lacey Act, as well as prohibiting their transport between the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, and any possession of the United States (18 U.S.C. 42, as amended).

The majority of injurious listings were made when the species were not established in the United States. A review of these listings suggests the resulting importation prohibitions have been effective in preventing invasions; no species that was absent from the United States at the time the Service listed it as injurious has become established (S. Jewell, U.S. Fish and Wildlife Service, personal communication). However, a species may be listed as injurious without being harmful (that is, become established, spread, and cause harm). For example, a species may have a venomous bite, be poisonous to consume, or convey a harmful pathogen—all of which could cause injury to humans or native wildlife without the subject species being capable of establishment and spread in the United States, typically required for a species to be considered "invasive."

To aid in efficiency and effectiveness of injurious wildlife listing, the Service has invested in tools and resources for risk assessment that consider a wide variety of factors that can contribute to invasiveness or injuriousness. These factors—including species biology and ecology; distribution; pathways of spread; and potential for ecological, human health, and economic impacts—distinguish the Service's tools from other, more narrowly-focused invasive species risk assessment methodologies. The availability of such broad-based tools benefits not just the Service, but also other jurisdictions with the authority to regulate possession or trade of live animal species.

The Service developed the Freshwater Fish Injurious Species Risk Assessment Model ("FISRAM") to advise the prioritization of species that might pose invasive or otherwise injurious threats to the United States. Variables representing species attributes, such as climate association and habitat requirements, as well as life history traits and invasion history, are used in the model to determine the potential threat posed by freshwater fish species introduced to U.S. ecosystems, with the probability of injuriousness represented in the model output. Presenting potential injuriousness in a probability structure facilitates use in a risk analysis framework. Additionally, FISRAM can help identify and document the various ecological and anthropogenic factors that could lead to the invasiveness or non-invasive injuriousness of freshwater fish species, and how changes in each factor affect the predicted probability of injuriousness.

Acknowledgments - The Freshwater Fish Injurious Species Risk Assessment Model (FISRAM) was innovated and produced by an interagency team of biologists, managers, and researchers: Bruce G. Marcot, U.S. Department of Agriculture–Forest Service, Portland, Oregon; Michael H. Hoff, U.S. Department of the Interior (USDI)–Fish and Wildlife Service, Bloomington, Minnesota (retired; Washburn, Wisconsin); Craig D. Martin and Susan D. Jewell, USDI Fish and Wildlife Service, Falls Church, Virginia; and Carrie E. Givens, USDI Fish and Wildlife Service, Falls Church, Virginia (currently with U.S. Geological Survey, Lansing, Michigan). Marcot acknowledges the support of Pacific Northwest Research Station, Forest Service, for his participation. Mention of commercial products does not necessarily entail endorsement by the U.S. Federal government and the agencies listed here.

Part Two: The Model

Brief Introduction to Bayesian Networks

The goal of this section is to introduce terminology and concepts that are specifically useful for understanding the structure and operation of FISRAM. A FISRAM user is not required to have an in-depth understanding of Bayesian statistics or Bayesian network modeling to use FISRAM appropriately.

A Bayesian network is a type of statistical model consisting of variables, represented as "nodes," that are connected via conditional probability distributions to form a "network." Nodes can represent constants, variables, and functions, but because FISRAM exclusively uses nodes to represent categorical variables, the rest of this section will focus on that type of node exclusively. Connections between nodes are directional and represent logical, correlational, or causal relationships between the nodes they connect (McCann et al. 2006). Bayesian networks are acyclic (Pearl 1988), that is, starting at a node and following the directional linkages from node to node will never bring one back to a node that has already been visited.

Nodes (representing categorical variables) have an associated probability distribution that defines the probabilities for the possible values, or states, that the variable can take. If a node has other nodes linked to it, then the probabilities are conditional on the state of the other nodes, which are known as its "parent nodes." Because the model is acyclic, some nodes serve as inputs with no parent nodes. At least one node will not lead to other nodes; this is referred to as an "output node."

The underlying probability distributions associated with input nodes are known as unconditional prior probabilities, and the distributions associated with the intermediate and output node(s) are conditional probabilities. When a Bayesian network is run, typically the user specifies the values of the input states, and the model then calculates the resulting outcomes in the other nodes of the model, based on their values and the underlying conditional probability distributions (McCann et al. 2006).

There are several reasons to use a Bayesian network modeling approach. First, a Bayesian network model provides a flexible structure in which expert experience and knowledge can be combined with quantitative, empirical data. Second, this approach provides a structure for dealing with missing data (if needed) by defaulting to prior knowledge. Third, this approach provides a means of easily calculating sensitivity and influence of outcomes to covariates, model segments, input data, and underlying probability structure.

Introduction to FISRAM

FISRAM is a Bayesian network designed to estimate the potential injuriousness of a freshwater fish species based on a combination of species traits, historical evidence of harm, and environment of the established range of the species relative to the potential region of introduction. As noted in Part One, a species does not have to be invasive (capable of establishment and spread as well as harm) to be federally listed as injurious, so traits associated with both invasiveness and injuriousness were included in the model. The FISRAM model is downloadable from the Australasian Bayesian Network Society's website: https://abnms.org/bn/198.

The FISRAM network (Fig. 1) consists of twenty linked nodes. There is a single output node, Injuriousness, with three possible states: No, Yes, Evaluate Further. These states represent the probabilities, respectively, that a species is not injurious, that it is injurious, and that further evaluation is needed because the potential for harm may be high even if the species is unlikely to establish and spread. Aside from the output "Injuriousness" node, any other node in the network, such as the intermediate nodes “Establishment” and “Spread,” could also be inspected for their state probabilities for low, medium, and high potential, should that information also be of value.

The model includes 11 input nodes to specify species and environmental attributes: Habitat Disturbance, Predation, Competition, Bites & Toxins, Genetics, Other Trait, Pathogens, Human Transport, Non-Human Dispersal, Habitat Suitability, and Climate 6 Score (an index of climate suitability). Eight intermediate nodes combine the effects of the input variables to determine the output probability distribution. The variables represented by the intermediate nodes include Behavioral Effect, Ecosystem Effect, Species Effect, Human Effect, Harm, Transport, Establishment, and Spread. Full definitions of all nodes are provided in Appendix A. Marcot et al. (2019) provide more detail on the process used to identify these nodes and their relationships in the model.

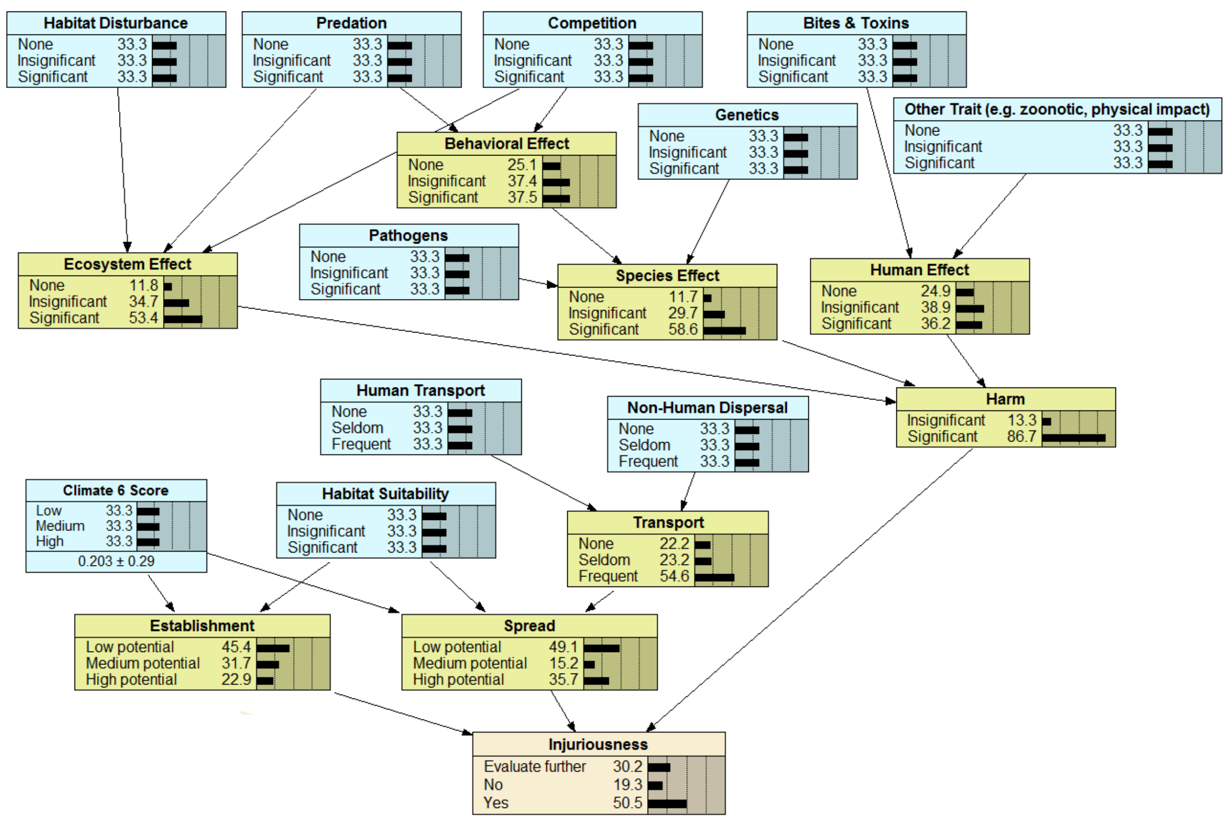

Figure 1. Bayesian Network Freshwater Fish Injurious Species Risk Assessment Model (FISRAM). The 11 input nodes are shown here in blue boxes, each parameterized with uniform prior probability distributions. The eight intermediate nodes are shown here in yellow boxes, with probability distributions determined by the input nodes influencing them and by their underlying conditional probability tables. The final output node is shown here in a tan box, with the posterior probability distribution for injuriousness of a species for which there is complete uncertainty about all inputs (the model default state).

The development of FISRAM included repeated sensitivity analysis (following Marcot 2012) to ensure that nodes were appropriately sensitive to immediate parent nodes and input nodes. Further, the initial probability relationships determined for FISRAM were tested and calibrated using 50 freshwater fish species of known degrees of invasiveness and injuriousness. In tests with this species set, the model discriminated correctly between known invasive and known noninvasive species, using the dominant probability state in the output node as the model results for each species. Of course, FISRAM is intended to apply primarily to species for which invasiveness and injuriousness are unknown prior to analysis.

Conditional probability distributions for the intermediate and output nodes were determined through the model development process, and then updated by training the model with the 50 cases of fish species with known outcomes of invasiveness and injuriousness (Marcot et al. 2019). For each individual model run, the probability distributions for intermediate nodes and the output node are calculated using Bayes' calculus based on the probability distributions of the input nodes and the underlying conditional probability tables. By default, the input nodes have uniform distributions, that is, all states of a node have equal probability (Fig. 1). These uniform distributions are applied only to calculation of posterior probabilities when there is a complete lack of knowledge and complete uncertainty in the values of the input variables. When inputs are determined by an assessor as described in Part Four, the probabilities assigned by the assessor replace the default probability distributions.

History of Model Development

FISRAM was developed and evaluated by a team of managers, biologists, and researchers (see Background). Members of this team reviewed policy, guidelines, mandates, and recommendations pertaining to factors influencing species invasiveness or injuriousness (ANSTF 1996; Lodge et al. 2006; NISC 2008), as well as peer-reviewed literature and expert knowledge, to develop the model structure and derive conditional probability values linking model variables. This work resulted in the "alpha" level model (following Marcot 2006).

The team then subjected this draft version of FISRAM to structured peer review following published procedures (Marcot 2006, Marcot et al. 2006), using five independent expert reviewers with expertise in invasive species biology, invasive species risk assessment, decision-support modeling, aquatic species biology, aquaculture, fisheries, and invasive species policy. Peer reviews were held in individual online sessions by lead B. Marcot. The five expert reviewers provided comments and suggestions for model improvement. B. Marcot provided the comments without attribution to team members M. Curtis, C. Givens, M. Hoff, S. Jewell, and C. Martin, who addressed all comments and revised the model as needed. All peer review comments and the Service's response to those comments are available to the public on the Service's website (https://www.fws.gov/fisheries/ans/erss_supporting_documents.html). The outcome of the peer review process and resulting revisions was a final, "beta" level model (Marcot et al. 2019).

Part Three: General Guidelines

Citing FISRAM

FISRAM should be referenced using the citation for the peer-reviewed journal article describing the model and its development:

Marcot, B.G., Hoff, M.H., Martin, C.D., Jewell, S.D., Givens, C.E. 2019. A decision support system for identifying potentially invasive and injurious freshwater fishes. *Management of Biological Invasions* 10(2): 200–226, https://doi.org/10.3391/mbi.2019.10.2.01

Administrative Record

A complete Administrative Record for an application of FISRAM provides thorough documentation of model results as well as the sources and decision-making used in generating model inputs. The Administrative Record includes the following documents (more detail on each of these documents is provided in Part Four):

- A completed spreadsheet from each assessor including documentation of information sources, relevant information gathered from those sources, probabilities assigned to FISRAM input nodes, and justification of the assigned probabilities;
- Any sources of information used in assigning probabilities to FISRAM input nodes, if not proprietary;
- A case file for each unique set of inputs for which FISRAM was run;
- A PDF of the model image for each unique set of inputs for which FISRAM was run; and
- When multiple assessors were involved, a written description of how inputs or outputs from these assessors were combined.

Recommended Applications of FISRAM

The peer-reviewed "beta" version of FISRAM is part of a broader decision-advisory framework that the Service has developed to determine the potential for invasiveness or injuriousness if a freshwater fish species is introduced and to inform their deliberations on whether to list a given species as injurious. The Service may also list species that are not themselves invasive or injurious but that serve as hosts or carriers for pathogens or parasites that have injurious effects on other populations of the same fish species or on other species; FISRAM can be used as supporting documentation for those listing regulations as well.

For the Service, FISRAM is to be used in conjunction with other decision support tools, particularly Ecological Risk Screening Summary reports ("ERSS", USFWS 2016); Figure 2). The ERSS is a rapid risk screening tool using two variables—climate match (climate similarity between where the species is currently established and climate within the United States) and history of invasiveness globally—to determine the level of risk posed by a species that has been introduced or could be introduced to the United States. The choices of risk classifications in the ERSS process are "high," "low," and "uncertain" risk. Species with an "uncertain" risk classification following the ERSS process are of limited value for informing injurious listing evaluations; therefore, FISRAM was developed for a segment of the taxa (fish) to help the Service refine the "uncertain" risk classification using species attributes. More information on the ERSS process, including completed ERSSs, is available on the Service's website (https://www.fws.gov/fisheries/ans/species_erss.html).

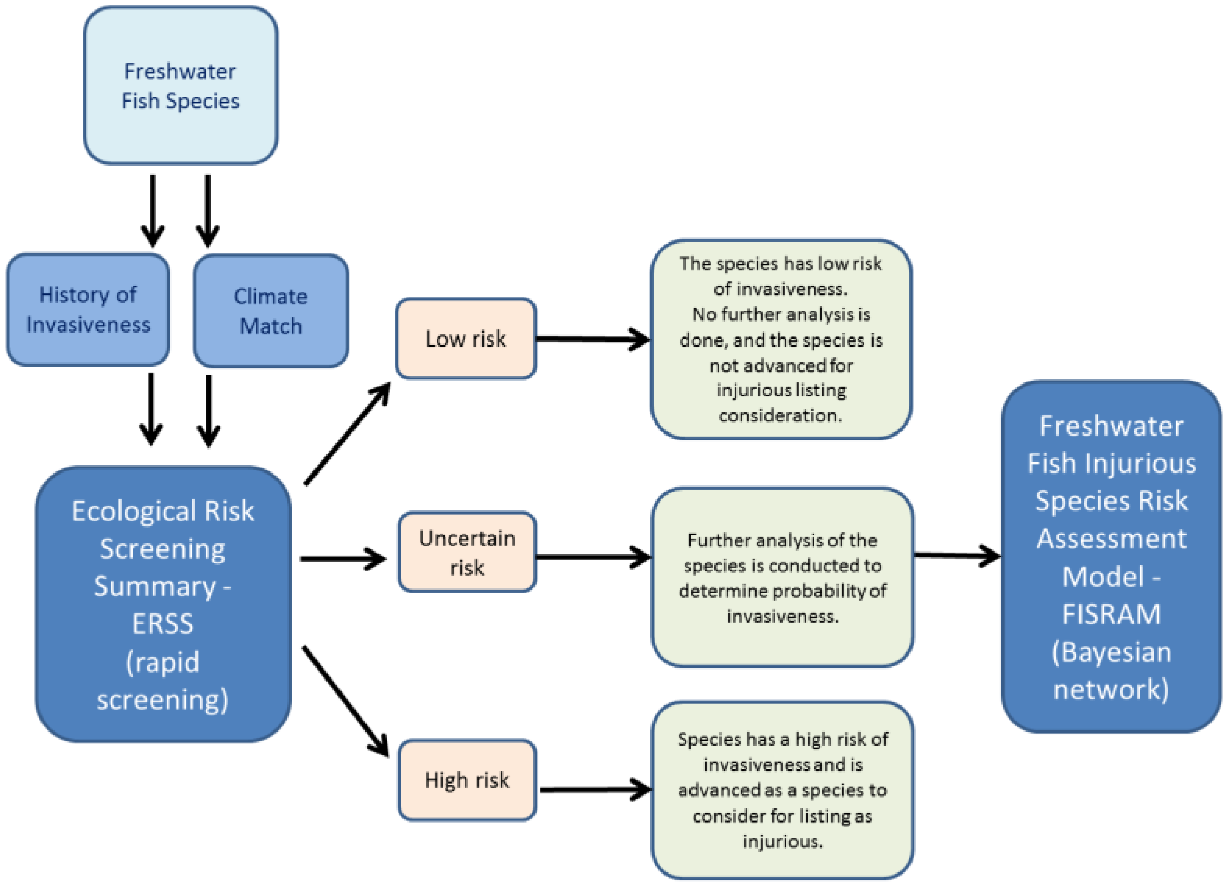

Figure 2. Flow chart depicting the connection between the Ecological Risk Screening Summary (ERSS) process and the Bayesian network Freshwater Fish Injurious Species Risk Assessment Model (FISRAM).

FISRAM can also be used by local, State, and other Federal agencies to help prioritize which species to manage as potentially invasive and to identify aspects of a species' biology on which to focus management efforts. Two efforts have been undertaken thus far using FISRAM to inform State management decisions; the results of one are publicly available (Wyman-Grothem et al. 2018).

When used outside the context of injurious species listings, the inputs to FISRAM and their variability across assessors may be particularly important outcomes of the modeling process. For example, the State of Michigan focused on assessor uncertainty and concerns over concurrent pathogen introduction revealed through FISRAM to determine what regulations to place on a new aquaculture facility for *Anguilla mossambica* (African longfin eel; Wyman-Grothem et al. 2018). Therefore, agencies or entities can find immense value in the structure provided by FISRAM for data collection and solicitation of expert knowledge for management issues other than injurious listings.

Multiple Expert Assessment

One of the major benefits of FISRAM is its ability to combine expert knowledge with quantitative, empirical data. The use of expert knowledge facilitates decision-making about complex systems when time and resources are limited for answering questions with protracted empirical monitoring and research studies (Martin et al. 2011), a common situation in invasive species prevention and management. However, expert knowledge can suffer from the effects of cognitive biases, such as overemphasis on evidence that is convenient relative to all available evidence, loyalty to an initial estimate, overconfidence in judgments (Morgan 2014), and other types of cognitive biases. An expert may also be influenced by their own mood during the period of assessment, or the way in which they interpret questions asked of them (Sutherland and Burgman 2015).

Clemen and Winkler (1999) describe the use of multiple experts as a "subjective version of increasing the sample size in an experiment." Multiple experts are unlikely to all be influenced by the same cognitive biases, or in the same direction, so groups tend to outperform individuals in answering scientific questions (Sutherland and Burgman 2015). Therefore, it is recommended that, in most applications of FISRAM, a group of at least three individuals with diverse expertise and experiences conduct the assessment. There are diminishing returns on the benefits of multi-expert assessment with more than three to five experts (Clemen and Winkler 1999). Multi-expert assessment may not be necessary when there is overwhelming speculative or anecdotal evidence of the impacts or lack of impacts of species introduction, especially if documented in peer-reviewed published sources, such that different individuals would be expected to come to the same conclusions about the available information on the species.

When multiple experts provide input probability distributions for FISRAM, there are a variety of ways in which these inputs can be combined and summarized. Methods for combining the contributions of multiple experts can be roughly divided into mathematical (using summary statistics or modeling) and behavioral (involving expert interaction) methods (Clemen and Winkler 1999). Because behavioral methods generally do not perform quite as well as mathematical methods (Clemen and Winkler 1999), this Standard Operating Procedures (SOP) recommends avoiding interactions among experts and using mathematical methods to combine multiple expert contributions, if combinations are sought. Furthermore, simple combination rules, like taking a mean, tend to perform well among mathematical combination methods (Clemen and Winkler 1999) and are recommended unless there is a compelling reason to use more complex methods. The modeler has the option to combine the inputs of multiple experts before the model is run, leading to a single run of the model based on the combined inputs and therefore a single result, or to run the model individually for each set of expert inputs and then either combine results into a single output or compare individual output results as an indication of the difference in knowledge and judgment among experts.

Part Four: FISRAM Implementation

Software Requirements

Assessors, or individuals who research the species of interest and provide input values for the model will benefit from access to Microsoft Excel (by Microsoft of Redmond, Washington) to complete a spreadsheet recording their collected data and inputs. Modelers, or individuals who use the inputs provided by assessors to calculate model output will need access to Netica (by Norsys of Vancouver, British Columbia, Canada), a program for developing Bayesian networks. A free limited version of Netica can be downloaded from the Norsys website (https://www.norsys.com/download.html). FISRAM can be run on the limited version, but any changes to the model file (.neta) cannot be saved.

Identifying Species Experts

To ensure a scientifically credible output, the inputs to FISRAM must be provided by an individual or group of individuals with a high level of expertise. FISRAM is not intended for use in initial risk screenings, so species assessed with FISRAM are typically those for which the initial screening could not make a definitive assessment of risk based on the available data. If published information that adequately addresses the input variables is not available, then to avoid similarly ambiguous results from FISRAM as from ERSS, an assessor must be able to go beyond the published literature on the species. Part of the power of FISRAM comes from its ability to harness expert knowledge by the assessors.

The first place to look for suitable assessors is among scientists who study the species to be assessed. Beyond personal contacts, such individuals can be identified by examining the authorship of published literature on the species and reaching out to these individuals. Preference should be given to scientists who study the ecology of the organism over those who study individual biological components.

Particularly for multi-expert assessments, other types of experts can make important contributions, and diverse groups of experts tend to outperform homogenous groups (Sutherland and Burgman 2015). Expertise that may be useful includes knowledge of congeneric species native to the introduction location, an understanding of the species of interest in other locations where it has been introduced, and experience with the invasion biology of fishes. Depending on the species of interest, it may be useful to include an expert on fish health or an expert on community interactions in the introduction location. The information collected in the ERSS (see below) can help suggest areas of expertise that are particularly relevant for the species of interest.

Collecting Species Data

Before FISRAM is implemented, an Ecological Risk Screening Summary (ERSS) should be completed for the species of interest. ERSSs are available for hundreds of species on the Service's website (https://www.fws.gov/fisheries/ans/species_erss_reports.html). Assessment of additional species can be requested by partner agencies or the public by emailing prevent_invasives@fws.gov. The ERSS is designed to succinctly summarize available information on a species, with an emphasis on information relevant to the assessment of risk of introduction, establishment, and harm. It also provides a list of relevant references that can be a starting point for further research into the species.

Assessors should each be provided a packet of information including the species ERSS, any other known risk assessments for the species, definitions of FISRAM nodes (Appendix A), a blank spreadsheet for providing inputs and documenting information sources (Appendix B), and an example of a completed spreadsheet (Appendix C). This set of files will guide the assessor in knowing what information to collect and how to document it, and provide a starting place for searching the literature.

Assessors should search for information relevant to the set of FISRAM inputs using the following sources:

- Ecological Risk Screening Summary, and references cited therein
- Published peer-reviewed literature, found by searching such sites as: Google Scholar (https://scholar.google.com/), an academic search engine such as Web of Science (http://webofknowledge.com; requires subscription[1]), WorldCat (https://www.worldcat.org/)[2], or local institutions' library catalogs
- CABI Invasive Species Compendium (http://www.cabi.org/isc/)
- USGS Nonindigenous Aquatic Species Database (http://nas.er.usgs.gov/queries/spsimplesearch.aspx)
- Personal files that may contain relevant unpublished data or reports
- Colleagues who may be able to provide unpublished data or reports
- "Gray literature," such as websites, newspapers, and reports produced by reputable sources and found through general search engines, such as Google (https://www.google.com).

Assessors should critically evaluate information sources and increase their level of skepticism in the information in inverse to the rigor of review to which the information source was subjected. Primary and peer-reviewed sources should receive priority, and other sources used to fill gaps as needed. If very little information is available on the species of interest, an ecologically and biologically similar species may be used as a "surrogate." Assessors should use information from a surrogate species only when confident that it is appropriate to do so—that is, there is rigorous justification that information on the congener likely reflects similar conditions of the species of interest—and should explain and state their level of confidence and areas of key uncertainties. Importantly, it should be remembered that sometimes even closely allied congeners can have drastically different behaviors, resource use patterns, and habitat associations.

The following search techniques and data sources are recommended for the FISRAM inputs specified:

- Genetics: Use the Global Biodiversity Information Facility (http://www.gbif.org/species) to determine whether the species of interest has congeners in the United States. Run a search on the genus, as well as any other species known to hybridize with the species of interest and view their distribution maps. Note which species are present in the potential region of introduction.
- Pathogens: Consult the World Organisation for Animal Health (http://www.oie.int/animal-health-in-the-world/) for a list of notifiable diseases for fish. Pay particular attention to whether the species of interest is susceptible to or a carrier of the pathogens that cause any of these diseases.

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[1] Service staff can receive a subscription to Web of Science by registering at the link given using their Service email.

[2] Service staff can access a customized version of WorldCat at https://fwslibrary.on.worldcat.org/discovery.

- Climate 6 Score: If the potential region of introduction is the contiguous United States, the Climate 6 score will be available from the species ERSS. If the assessment is conducted for a different region of introduction, the Service's Risk Assessment Mapping Program ("RAMP"; USFWS 2018) can be used to calculate the Climate 6 score for that region. Assessors are only responsible for calculating this score if they have proper training and access to RAMP. Otherwise, it must be provided by someone who is trained in RAMP.

Assessors should use the blank spreadsheet (Appendix B) to list data sources and collect relevant information for each node. Refer to the node definitions (Appendix A) as frequently as needed. Make sure to clearly document in the spreadsheet any uncertainty or discrepancies in data or information, and note where personal expert knowledge was used or if information is unavailable for any given input variable. The completed example spreadsheet (Appendix C) can provide guidance on the format and amount of information to include, although level of detail will depend on the information available on the species of interest.

Estimating Node Probabilities

After collecting and documenting information on each FISRAM node, assessors are responsible for translating this information into the probabilities that will be used as input into FISRAM. As explained in Part Two, each input node, except Climate 6 Score, can take multiple discrete states, for example, "None," "Insignificant," and "Significant." Following the rules of probability, the probabilities assigned to the states of a given node must all sum to 1, and the probability for each state should be between 0 and 1. For Climate 6 Score, the calculated value can be used directly as model input and no probabilities need to be assigned manually.

Assessors should use the definitions of each node state (Appendix A) to guide their assignment of probabilities. For example, it might be that the species of interest is known to feed heavily on aquatic macrophytes and reduce macrophyte abundances, and that native species depend on aquatic macrophytes for nursery habitat. In this case, for the input variable Habitat Disturbance, the states "None" and "Insignificant" might each be assigned probabilities of 0 and the state "Significant" a probability of 1. Alternatively, perhaps the species might have an effect on habitat of native species but it is not known to what degree; in this case, "None" could be assigned a probability of 0 and "Insignificant" and "Significant" could each be assigned equal probabilities of 0.5.

If absolutely no information is known for a node, equal probability can be given to each state of the node by relying on the default uniform probability distribution of the node (for example, probabilities of 0.33, 0.33, and 0.33 for a node with three states). However, expert judgment can usually suggest a probability distribution that is not equal across all states using surrogate species or anecdotal information, with appropriate and credible justification.

Assessors should provide comments showing defensible reasoning behind the probability values assigned to each state for each input variable. These comments can be helpful when comparing the probabilities assigned by different assessors. Spreadsheets, including the assigned probabilities for all states and the rationale for assigning those probabilities, should be saved to the Administrative Record.

Running FISRAM with Netica

The following steps detail the process of running the FISRAM model based on the inputs provided by one or more assessors. The person running the model is referred to as the "modeler";

the modeler may or may not also be an assessor depending on their relevant skills. For simplicity, these steps describe the case when a single set of inputs from a single assessor are run through the model; approaches for combining inputs from multiple assessors are discussed in Part Three, above.

1. Open the Netica program on a Windows-based computer.
2. Open the Netica file "FISRAM Freshwater Species 140812a (w 33-33-33 priors) EM 2016.neta".
3. Input probability values for the states of each input node as follows:
    a. Right-click on an input node (e.g., Habitat Disturbance).
    b. Select "Enter Finding", then "Likelihood … ."
    c. Enter probability values between 0 and 1 for each state as prompted, clicking "OK" to move to the next state. The name of the state is given after the vertical bar in the probability expression, for example, the prompt "Enter P(Observation | HabDis=None)" asks for the probability of the state "None" for node "Habitat Disturbance" (see Appendix A for node abbreviations). Select "Revert" as needed to return to the default value for the node.
    d. After probabilities for all states of a node have been entered, the prompt window disappears and the model now shows the entered probability values for all states. Note that Netica displays the node probabilities as percentages (0 to 100 scale) rather than proportions (0 to 1 scale).
    e. In case of error, probability values can be reentered by repeating step 3 from the beginning.
    f. If the modeler does not input probability values for a particular parent node, the model will retain its default values of equal (uniform) probabilities across all its states.
4. Do not change probability values for any nodes other than the input variable nodes (color-coded blue on the model).
5. The model processes information as the modeler enters it. As probabilities are entered for each input node, the final node, Injuriousness, will display the resulting probabilities of its states, that is, for "Evaluate Further," "No" (not injurious), or "Yes" (is injurious). Record these probability values for "Evaluate Further," "No," and "Yes" in the relevant assessor's spreadsheet for the Administrative Record after all probabilities are entered for all input nodes.
6. Save the probability inputs and resultant model output in a case file (.cas) that can be read by Netica. Case files are simple text files in ASCII format, and can be edited, if needed using any text editor that can save the modified file in simple text ASCII format. The case file allows the modeler to reload the probability inputs into the model (to rerun the model and produce the same results). Do this from Netica's "Cases" menu with the option to "Save Case" or "Save Case As …". The case file should be saved with relevant identifying information (species name, date, modeler name) in the file name, and added to the Administrative Record. In the future, reopen the case file in Netica by first reopening the Netica file ("FISRAM Freshwater Species 140812a (w 33-33-33 priors) EM 2016.neta"), then choosing "Get Case…" from Netica's "Cases" menu and navigating to the appropriate case file.
7. Print the probability inputs and resulting model output to a PDF so that the model image, with input and output values, can be viewed outside of Netica. Use the "Print…" option

in Netica's "File" menu. Save the PDF to the Administrative Record. If the PDF does not display the model image at an appropriate size, adjust the settings under "Printer Setup…" or, in the dialog box that pops up after closing "Printer Setup," enter "1" as "Size printing to fit on X pages horizontally."

8. Finally, you can save the Netica model showing it running for a particular species as part of the documentation. (NOTE that this functions only in the purchased and registered version of Netica, and does not work in their free limited version.) Do this in Netica by going to the menu item File / Save As, and specifying a new file name. This creates a ".neta" file that can also be used for the Administrative Record. Specify the new file name to include the species' name, your name, and date, and save it in a shared drive folder pertaining to the FISRAM Bayesian network model.

Presenting Results from FISRAM

Presentation of FISRAM results will depend on whether the modeling process involved a single assessor or a group of assessors, and whether it involved a single run of the model or multiple runs of the model. The style of presentation also depends on the motivation for using FISRAM, that is, whether the primary purpose was to generate an estimate of injuriousness (output focused) or to identify particularly concerning biological traits or areas of uncertainty (input focused).

With an output focus, the probability distribution can be reported verbally as the result of a single model run or as an arithmetic, geometric, or weighted mean of multiple model runs. In the case of multiple model runs, presenting the variability or range of model outputs either verbally (for example, "the range in predicted probability of injuriousness was extreme across assessors (0.15 – 0.89)") or graphically (Fig. 3) is also recommended.

Figure 3. Example of a bar plot of the results of multiple FISRAM model runs. Individual results generated from individual expert input values are represented by black dots. The arithmetic mean of output probabilities for each state is represented by the shaded bar. Figure modified from Wyman-Grothem et al. (2018).

With an input focus, similar methods can be used to present probability distributions, although the distributions reported will be inputs rather than the output. With an input focus, it also becomes especially important to report on the justifications provided by the assessor(s) in assigning input probability distributions. Verbal justifications can provide valuable information for risk mitigation, such as which pathogens are of greatest concern for introduction or which native species are at greatest risk of predation.

Finally, it is crucial to report the methods used to obtain the results of FISRAM because of the many ways in which the model can be implemented. Such methods should include the number of assessors and how they were selected, whether any motivation was given to encourage assessor participation, and the information provided to the assessor(s). For applications with multiple assessors, also include whether assessors interacted at all while generating input probability distributions, and how multiple assessor inputs were combined if at all.

Part Five: References

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Appendix A: Definitions

General Definitions

A **nonnative species** is defined as "'Non-native species' or 'alien species' means, with respect to a particular ecosystem, an organism, including its seeds, eggs, spores, or other biological material capable of propagating that species, that occurs outside of its natural range" (White House 2016).

An **introduction** "means as a result of human activity, the intentional or unintentional escape, release, dissemination, or placement of an organism into an ecosystem to which it is not native" (White House 2016).

Where the species under assessment can affect other species, **potentially affected species** include all native species, Federal trust species and other trust resources and responsibilities (including threatened and endangered species and migratory birds), and State-managed species.

"**Affect**" may include magnitude, intensity, and duration of negative impact. [See 42 U.S.C. 4371 et seq., 40 CFR 1508.27.]

Node Definitions

Habitat Disturbance (HabDis)

Definition

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, trophic effects, etc. for affected species.

States

- **None**: No species' habitat negatively affected; introduction of this species in no way modifies the habitat of any potentially affected species.
- **Insignificant**: One or more species' habitat(s) negatively affected but in a minor way; for example, the effect is present only during a non-critical period or the effect is such a low level that it does not alter the behavior and health or abundance of potentially affected species.
- **Significant**: One or more species' habitat(s) negatively and substantially affected such that it alters the behavior and health or abundance of potentially affected species.

Comments, citations

Wildlife or habitat damages that may occur from control measures are included.

Based on jurisdictional impact; could include more limited effects on resources, such as in one State or ecosystem or within a state or a region within the United States. For injurious wildlife listings, habitat disturbance would need to occur among two or more states or other jurisdictional boundaries.

Potentially affected species include all native species, federal trust species and other trust resources and responsibilities (including threatened and endangered species and migratory birds), and State-managed species. "Affect" may include magnitude, intensity, and duration of negative impact. [see 42 U.S.C. 4371 et seq., 40 CFR 1508.27]

Predation (Pred)

Definition
The capacity of the nonnative species to adversely affect populations of native species (animals, plants, and others) by predation.

States

- **None**: No species' population negatively affected; this introduced species does not prey on any potentially affected species.
- **Insignificant**: One or more species' population(s) negatively affected but in a minor way; for example, the effect is such a low level that it does not alter the behavior and health or abundance of potentially affected species.
- **Significant**: One or more native species' populations negatively and substantially affected such that it alters the behavior and health or abundance of potentially affected species.

Comments, citations
"Affect" may include indirect effects of selective loss of genotypes and changed gene pool as a result of direct predation.

Competition (Comp)

Definition
The capacity of the nonnative species to adversely affect native species through competition for food, space, or habitat.

States

- **None**: No species' population negatively affected; this introduced species does not compete with any of the potentially affected species.
- **Insignificant**: One or more species' population negatively affected but in a minor way; for example, the effect is present only during a non-critical period or the effect is such a low level that it does not alter the behavior and health or abundance of potentially affected species.
- **Significant**: One or more species' populations negatively and substantially affected such that it alters the behavior and health or abundance of potentially affected species.

Comments, citations
Potentially affected species include all native species, federal trust species and other trust resources and responsibilities (including threatened and endangered species and migratory birds), and State-managed species. "Affect" may include magnitude, intensity, and duration of negative

impact. “Affect” may also include indirect effects of selective loss of genotypes and changed gene pool as a result of direct competition. [see 42 U.S.C. 4371 et seq., 40 CFR 1508.27]

Genetics (Gen)

Definition
The capacity of the nonnative species to adversely affect populations of the native species through direct genetic influences including hybridization, genetically modified organisms (GMOs), and introgression.

States
- **None**: No species' population genetics negatively affected; this introduced species does not influence the genetics of any potentially affected species. No native or State-managed congeners in the United States.
- **Insignificant**: One or more species' population genetics negatively affected but in a minor way; for example, the effect is present only during a non-critical period or the effect is such a low level it does not alter the behavior and health or abundance of potentially affected species.
- **Significant**: One or more species' populations negatively and substantially affected such that it alters the behavior and health or abundance of potentially affected species.

Pathogens (Path)

Definition
Epizootic; infectious diseases are caused by pathogenic microorganisms such as bacteria, viruses, parasites, or fungi; these pathogens and parasites can be spread, directly or indirectly, from one animal to another. Includes pathogens that cause OIE-reportable diseases (OIE 2018).

States
- **None**: No species' population negatively affected; this species is not involved in the spread (direct or indirect) of any pathogen or parasite.
- **Insignificant**: One or more native species' population negatively affected but in a minor way such that the effect is at a low level and does not alter the behavior and health or abundance of potentially affected species. Some signs or symptoms develop as a result of exposure, but minimally bothersome and generally resolved rapidly with no residual disability or disfigurement; or signs or symptoms more pronounced, more prolonged, or more systemic than minor symptoms, with some form of mild treatment usually indicated; symptoms not life-threatening; no residual disability or disfigurement.
- **Significant**: One or more native species' populations negatively and substantially affected such that it alters the behavior and health or abundance of potentially affected species. Signs or symptoms are life-threatening or result in significant residual disability or disfigurement; or death resulting from exposure or from direct complication of the exposure. May or does affect more than isolated cases.

Comments, citations
A pathogen is a bacterium, virus, or other microorganism that can cause disease. A disease is a condition of a living animal or plant body or one of its parts that impairs normal functioning. If

species is a fish, crustacean, or amphibian, then specifically state whether disease is OIE-reportable. Visit the website (http://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2019/) (OIE 2019) for current listing of OIE-reportable diseases.

Bites & Toxins (BiteTox)

Definition

Direct adverse effect on human health from bites, stings, or other injections, ingestion, skin contact, or absorption of venom from the nonnative species; or other consequences that lead to illness. Does not include effects from captive individuals; includes effects from wild and free-roaming individuals.

States

- **None**: No signs or symptoms as a result of exposure.
- **Insignificant**: Some signs or symptoms develop as a result of exposure, but minimally bothersome and generally resolved rapidly with no residual disability or disfigurement. Or signs or symptoms more pronounced, more prolonged, or more systemic than minor symptoms, with some form of treatment usually indicated; symptoms not life-threatening; no residual disability or disfigurement. May or does affect less than the population but more than isolated cases.
- **Significant**: Signs or symptoms life-threatening or resulting in significant residual disability or disfigurement; or death resulting from exposure or from direct complication of the exposure. May or does affect more than isolated cases.

Comments, citations

State definitions from: *American Association of Poison Control Centers' Annual Report of the National Data Poison System* (NPDS) (Bronstein et al. 2012). Report is available at https://aapcc.s3.amazonaws.com/pdfs/annual_reports/2011_NPDS_Annual_Report.pdf. A toxin is a product of metabolic activities of a living organism (includes poison by ingestion and contact and venom).

OtherTrait (OthTr)

Definition

Pertains to species traits that could impart adverse effect on human health from other than bites and toxins that lead to illness, injury, paralysis, or death; or any other trait that characterizes any form of risk to humans (such as damage to critical infrastructure).

States

- **None**: No impact on human health. No scientific information or scientific judgment describing other traits that should be included in assessment of injuriousness.
- **Insignificant**: Minor impact on human health. Some signs or symptoms develop as a result of exposure, but minimally bothersome and generally resolved rapidly with no residual disability or disfigurement. Or signs or symptoms more pronounced, more prolonged, or more systemic than minor symptoms, with some form of treatment usually indicated; symptoms not life-threatening; no residual disability or disfigurement. May or does affect less than the population but more than isolated cases. Scientific information or

scientific judgment describing other traits that document or assess minor impacts to agriculture, horticulture or forestry, and the welfare and survival of wildlife resources.

- **Significant**: Major impact on human health. Signs or symptoms are life-threatening or result in significant residual disability or disfigurement; or death resulting from exposure or from direct complication of the exposure. May or does affect more than isolated cases. Scientific information or scientific judgment describing other traits that document or assess substantial impacts to humans.

Comments, citations

Examples of traits include zoonoses and physical impacts (such as silver carp jumping out of water). Zoonoses are infectious diseases of animals that can cause disease when transmitted to humans. Other species traits may be included in the model, when either scientific study or expert judgment warrant. Example of damage to infrastructure is armored catfish, which burrow into levees and weaken them (ISAC 2016).

Human Transport (HumTrans)

Definition

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 it was established and can move from on its own.

States

- **None**: Not transported or transportable by humans, such as being very fragile or extremely large.
- **Seldom**: Rarely transported by humans.
- **Frequent**: Easily transportable by humans; or has been transported by humans to new range.

Comments, citations

Accidental includes hitchhiker organisms, such as in ballast and bilge water, pipelines, and canals. This includes human transport in another country in which it is invasive. Includes aquaculture.

Non-Human Dispersal (Disp)

Definition

Any assistance by non-human agents for moving the subject species from its current range beyond a range where it can move on its own.

States

- **None**: Not able to disperse without human assistance; requires Human Transport for dispersal.
- **Insignificant**: Rarely able to disperse or cannot disperse outside of a contained area without human transport assistance.

- **Significant**: Likely to disperse without human assistance; or it has dispersed without human assistance to new range. Includes having the ability to bypass barriers (such as jumping over barriers or digging through them).

Comments, citations
Includes, but is not limited to wind, water, host animals.

Climate 6 Score (Clim)

Definition
(Sum of Counts for Climate Scores 6-10)/(Sum of all Climate scores)

States
- **Low**: $0 \leq X \leq 0.005$
- **Medium**: $0.005 < X < 0.103$
- **High**: $X \geq 0.103$

Comments, citations
As defined in *Standard Operating Procedures for the Rapid Screening of Species' Risk of Establishment and Impact in the United States* (USFWS 2016).

Habitat Suitability (HabSuit)

Definition
Habitat that matches the known habitats of the species, whether in the indigenous or invasive range of the species.

States
- **None**: No suitable habitat for establishment or spread in the potential establishment or spread region.
- **Insignificant**: Habitat in the potential establishment or spread region is of the type that the species uses in mostly equal proportion to availability. Self-sustaining populations projected to establish in subject habitats, but biomass not projected to exceed that of any native, State-managed, or Federal trust species.
- **Significant**: Habitat in the potential establishment or spread region is of the type that the species uses in greater proportion than availability. Self-sustaining populations projected to establish in subject habitats, and biomass projected to exceed that of one or more native, State-managed, Federal trust species. Example includes Asian carps, which have denser populations in United States than in native ranges.

Comments, citations
Invasive range can be elsewhere in the world.

Ecosystem Effect (EcoEff)

Definition

Overall impact of habitat disturbance, predation, and competition on structure, function, trophic effects, and composition of ecosystems.

States

- **None**: No ecosystem structure, function, or composition is negatively affected; the introduced species does not modify habitat, prey, or compete with any potentially affected species.
- **Insignificant**: Some ecosystem structure, function, or composition is negatively affected but in a minor way; for example, the effect is present only during a non-critical period or the effect is such a low level that it does not alter the behavior and health or abundance of potentially affected species.
- **Significant**: Some ecosystem structure, function, or composition is negatively and substantially affected such that it alters the behavior and health or abundance of potentially affected species.

Behavioral Effect (BehEff)

Definition

The combined influence of predation and competition of the nonnative species on native species.

States

- **None**: No native species' population negatively affected; the species does not prey or compete with any potentially affected species.
- **Insignificant**: One or more native species' population negatively affected in a minor way; for example, the effect is present only during a non-critical period or the effect is such a low level it does not alter the behavior and health or abundance of potentially affected species.
- **Significant**: One or more native species' populations negatively affected such that it alters the behavior and health or abundance of potentially affected species.

Species Effect (SppEff)

Definition

Overall impact of predation, competition, and genetics on the viability of native species.

States

- **None**: No native species' population negatively affected; the species does not transmit pathogens to or alter the behavioral effects and genetics of potentially affected species.
- **Insignificant**: One or more native species' population negatively affected in a minor way; for example, the effect is present only during a non-critical period or the effect is such a low level it does not alter the behavior and health or abundance of potentially affected species.

- **Significant**: One or more native species' populations negatively and substantially affected such that it alters the behavior and health or abundance of potentially affected species.

Human Effect (HumEff)

Definition

Combined influence of bites and toxins, with other injury on humans.

States

- **None**: No humans negatively affected; the species does not impair human health.
- **Insignificant**: One or more humans negatively affected in a minor way. Some signs or symptoms develop as a result of exposure, but minimally bothersome and generally resolved rapidly with no residual disability or disfigurement. Or signs or symptoms more pronounced, more prolonged, or more systemic than minor symptoms, with some form of treatment usually indicated; symptoms not life-threatening; no residual disability or disfigurement. May or does affect less than the population but more than isolated cases.
- **Significant**: One or more humans negatively and substantially affected. Signs or symptoms life-threatening or result in significant residual disability or disfigurement; or death resulting from exposure or from direct complication of the exposure. May or does affect more than isolated cases.

Harm (Harm)

Definition

Actual or potential physical or behavioral injury or damage to native species and humans or natural and restored habitats.

States

- **Insignificant**: One or more native species' population or habitat negatively affected but in a minor way, or no native species or habitats are negatively affected in any way; for example, the effect is present only during a non-critical period or the effect is such a low level it does not alter the behavior and health or abundance of potentially affected species. In some cases, one or more humans negatively affected in a minor way. Some signs or symptoms develop as a result of exposure, but minimally bothersome and generally resolved rapidly with no residual disability or disfigurement. Or signs or symptoms more pronounced, more prolonged, or more systemic than minor symptoms, with some form of treatment usually indicated; symptoms not life-threatening; no residual disability or disfigurement. May or does affect less than the population but more than isolated cases.
- **Significant**: One or more native species' populations negatively and substantially affected such that it alters the behavior and health or abundance of potentially affected species. In some cases, one or more humans negatively and substantially affected. Signs or symptoms life-threatening or result in significant residual disability or disfigurement; or death resulting from exposure or from direct complication of the exposure. May or does affect more than isolated cases.

Comments, citations
Injury includes to potentially affected species and humans; damage includes to natural and restored habitats.

Transport (Transp)

Definition
The combined effect of any assistance by human or non-human agents (dispersal) for moving the subject species from their current range to where it can move on its own.

States
- **None**: Low likelihood of intentional or unintentional transport by humans or nonhuman vectors.
- **Seldom:** Some transport occurs but is minor (such as short distance or rare circumstances).
- **Frequent:** Species is in trade or is found in ballast, or is found regularly in other form(s) of transport. "In trade" can be anywhere in the world.

Comments, citations
This includes human transport in another country in which it is invasive.

Establishment (Estab)

Definition
Actual or potential intentional or unintentional establishment of self-sustaining population in the wild.

States
- **Low**: Habitat and climate conditions not suitable for reproduction and survival of recruits that result in self-sustaining populations.
- **Medium**: Habitat and climate conditions suitable for reproduction and survival of recruits resulting in self-sustaining populations in at least one location in the wild.
- **High**: Habitat and climate conditions suitable for reproduction and survival of recruits resulting in self-sustaining populations in several or many locations in the wild.

Comments, citations
"Location" refers to an actual or potential geographic occurrence of the species, where occurrence can be defined on a species-specific basis according to geographic 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.

Spread (Spread)

Definition
Actual or potential intentional or accidental spatial expansion by humans of temporary or permanent populations from one large ecosystem to another in the wild regardless of vector. Spread from one large aquatic ecosystem to another is defined by spread between two or more

states or between 2-digit Hydraulic Unit Codes or regions. Spread can be independent of establishment.

States

- **Low**: Habitat and climate conditions not suitable for species survival, and transportation mode not readily available.
- **Medium**: Habitat and climate conditions are either marginal for species survival, and transportation mode is present; or habitat and climate conditions are good for species survival but transportation mode not readily available; or habitat and climate conditions are suitable for species survival in a somewhat limited area in the wild, and transportation mode is present.
- **High**: Habitat and climate conditions are suitable for species survival, and transportation modes are readily available.

Comments, citations

The Nation is divided into 21 major geographic areas, or regions. These are measured as 2-digit HUCs (http://water.usgs.gov/GIS/regions.html) (USGS 2016).

Injurious (Injur)

Definition

A nonnative organism that establishes, spreads, and causes harm, or a nonnative organism that causes harm.

States

- **No**: Not invasive; low establishment potential, low spread potential, and insignificant harm.
- **Yes**: Invasive; significant harm coupled with medium to high establishment and spread potential.
- **Evaluate further**: Species has low potential for spread and establishment, but has high potential for harm.

Comments, citations

Refer to Harm definition. May or does cause significant harm to humans as defined in Bites & Toxins and Other Trait nodes; may or does cause significant harm to potentially affected species as defined in Ecosystem Effect and Species Effect node.

References

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USGS (U.S. Geological Survey). 2016. Hydrologic unit map. U.S. Geological Survey. Available: http://water.usgs.gov/GIS/regions.html. (August 2017).

White House. 2016. Executive Order 13751. Safeguarding the Nation from the Impacts of Invasive Species. Federal Register 81:236 (5 December 2016):88609-88614.

Appendix B: Data Documentation Spreadsheet

The following pages present a form for collecting information on a species of interest, reporting selected Bayesian network probabilities, and documenting the reasoning behind the probabilities assigned. A Microsoft Excel version of this form is available on request.

Species	**Habitat Disturbance**	**Predation**	**Competition**	**Bites & Toxins**	**Genetics**
[*Species scientific name*]					
References List references used to develop your input. Please supply copies of references.					
Bayesian Network Probabilities Enter probabilities (0.0-1.0) for each state except Climate6 Score. Your probabilities for all three in each cell must sum to 1.0.	None= [*Probability*], Insignificant= [*Probability*], Significant= [*Probability*]	None= [*Probability*], Insignificant= [*Probability*], Significant= [*Probability*]	None= [*Probability*], Insignificant= [*Probability*], Significant= [*Probability*]	None= [*Probability*], Insignificant= [*Probability*], Significant= [*Probability*]	None= [*Probability*], Insignificant= [*Probability*], Significant= [*Probability*]
Comments Add comments as appropriate to explain how you developed your probabilities. Level of details about comments listed herein need not be in dept. However, if warranted, then please submit a separate document explaining how you derived your probabilities.					
Risk Assessor Name = [*Your name*]					

Species	**Human Transport**	**Non-Human Dispersal**	**Pathogens**	**Habitat Suitability**	**Other Traits**
[*Species scientific name*]					
References List references used to develop your input. Please supply copies of references.					
Bayesian Network Probabilities Enter probabilities (0.0-1.0) for each state except Climate6 Score. Your probabilities for all three in each cell must sum to 1.0.	None= [*Probability*], Seldom= [*Probability*], Frequent= [*Probability*]	None= [*Probability*], Seldom= [*Probability*], Frequent= [*Probability*]	None= [*Probability*], Insignificant= [*Probability*], Significant= [*Probability*]	None= [*Probability*], Insignificant= [*Probability*], Significant= [*Probability*]	None= [*Probability*], Insignificant= [*Probability*], Significant= [*Probability*]
Comments Add comments as appropriate to explain how you developed your probabilities. Level of details about comments listed herein need not be in dept. However, if warranted, then please submit a separate document explaining how you derived your probabilities.					
Risk Assessor Name = [*Your name*]					

Appendix C: Example Completed Spreadsheet

The following pages present an example of a completed data documentation spreadsheet for the freshwater fish *Leuciscus idus* (ide). Complete data documentation would also include a copy of each information source cited in the spreadsheet.

Species	Habitat Disturbance	Predation	Competition	Bites & Toxins	Genetics
Leuciscus idus	No evidence	Feeds on vegetation and macro-invertebrates; larger individuals may consume other fish.	Potential for competition acknowledged, but no definitive research.	No evidence	Hybridizes with other European cyprinids, but not known to hybridize with any North American fishes.
References List references used to develop your input. Please supply copies of references.		CABI 2015	CABI 2015		CABI 2015
Bayesian Network Probabilities Enter probabilities (0.0-1.0) for each state except Climate6 Score. Your probabilities for all three in each cell must sum to 1.0.	None = 1.0 Insignificant = 0.0 Significant = 0.0	None = 0.33 Insignificant = 0.34 Significant = 0.33	None = 0.33 Insignificant = 0.34 Significant = 0.33	None = 1.0 Insignificant = 0.0 Significant = 0.0	None = 0.80 Insignificant = 0.15 Significant = 0.05
Comments Add comments as appropriate to explain how you developed your probabilities. Level of details about comments listed herein need not be in dept. However, if warranted, then please submit a separate document explaining how you derived your probabilities.		Impact is unknown.			No known hybridization with North American species, but much confusion exists around distribution in the U.S. and hybridization could have been overlooked. Known hybridization with European species not known to have major population impacts.
Risk Assessor Name = [redacted]					

Species	Human Transport	Non-Human Dispersal	Pathogens	Habitat Suitability	Other Traits
Leuciscus idus	Valued as an ornamental pond fish.	Able to disperse to new locations by swimming.	Susceptible to spring viraemia of carp (SVC), an OIE-reportable disease.	Not highly abundant in either native range or introduced range. Many formerly-established U.S. populations are no longer extant.	No evidence
References List references used to develop your input. Please supply copies of references.	ERSS	ERSS; CABI 2015	Dixon 2012	ERSS; CABI 2015	
Bayesian Network Probabilities Enter probabilities (0.0-1.0) for each state except Climate6 Score. Your probabilities for all three in each cell must sum to 1.0.	None = 0.0 Seldom = 0.0 Frequent = 1.0	None = 0.0 Seldom = 0.0 Frequent = 1.0	None = 0.0 Insignificant = 0.0 Significant = 1.0	None = 0.7 Insignificant = 0.3 Significant = 0.0	None = 0.0 Insignificant = 0.0 Significant = 1.0
Comments Add comments as appropriate to explain how you developed your probabilities. Level of details about comments listed herein need not be in dept. However, if warranted, then please submit a separate document explaining how you derived your probabilities.			SVC virus infects many species of fish and causes acute symptoms.	Majority of introduced populations of *L. idus* in the U.S. have failed or been extirpated. In some locations, reproducing populations have become established but abundance is not especially high.	
Risk Assessor Name = [redacted]					