

National Invasive Species Council Pathways Work Team

Focus Group Conference Report And Pathways Ranking Guide June 21 – 22, 2005



Figure 1 Scientific name: *Boiga irregularis*.
Common name: Brown Tree Snake



Figure 3 Scientific name: *Dreissena polymorpha*. Common name: Zebra mussel



Figure 2 Scientific name: *Anoplophora glabripennis*.
Common name: Asian Longhorned Beetle



Figure 4 Scientific Name: *Eichhornia crassipes*.
Common name: Water hyacinth

THE NATIONAL INVASIVE SPECIES COUNCIL (NISC)

Pathways Work Team Conference

Sponsored by:

Richard Orr
Assistant Director for International Policy and Prevention
National Invasive Species Council (NISC)
1201 Eye Street NW Fifth Floor Room 79
Washington DC. 20005

and

Alan S. Green
Executive Director, Plant Health Programs
Plant Protection and Quarantine (PPQ)
Animal and Plant Health Inspection Service (APHIS)
U.S. Department of Agriculture (USDA)
4700 River Road
Riverdale, MD 20737

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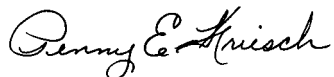
Executive Summary

This document represents the second version of a guide and process for pathway definition, analysis and prioritization. It is expected that this document will undergo another trial test and revision prior to full implementation, though we strongly believe this is a 'workable' product that only requires refinement.

Throughout this systems development process, the Pathways Work Team struggled with several issues relevant to scientific data and public policy. While this report in no way attempts to resolve such intricate issues, it is essential that these considerations be brought to the forefront for future decision-making efforts and as such are enumerated below:

- International competitiveness is impacted by invasive species
- Pathway ranking combines community, government and corporate interests
- Sound science, transparency and consistency are essential for formulating policy
- Neutrality is essential in providing scientific advice to decision makers
- Market and non-market forces must be analyzed for final decisions
- Invasive species prevention is inherently an international activity
- Methodology must include public, stakeholder and expert participation
- Assessment is to provide common perspectives
- Decisions must occur at individual agency levels
- Outcome of the process is the characterization of relative risk of pathways
- Policy makers must devise plans for pathway management, resource leveraging, policy development, budget decisions and technology transfer/development

In conclusion, the Pathways Work Team strongly supported the position that policy decides the direction to take (with human health, commerce, and then ecosystems being the priorities for ranking), but science must maintain the focus. ¹



Penny Kriesch, Chair
National Invasive Species Council
Prevention Committee
Pathways Work Team

¹ Source: Arizona State University Consortium for Science, Policy and Outcomes, College of Liberal Arts and Sciences

Pathways Work Team

Penny Kriesch
Agricultural Analyst
USDA APHIS

Faith Campbell
Senior Policy Representative
The Nature Conservancy

Jeffrey P. Fisher
Environmental and Scientific Affairs Analyst
Department of State

Susan D. Cohen
Policy Analyst
USDA APHIS

Sharon Gross
Assistant Program Coordinator
NISC

Pam Fuller
Center for Aquatic Resources Analyst
USGS

Jan Gilbreath
Office of International Affairs Analyst
U.S. Environmental Protection Agency

Vincent Guida
NOAA Fisheries Analyst
Department of Commerce

Michael Hennessey
Entomologist Pathways & Stndrd Team Ldr
USDA APHIS

Donald R. MacLean
Environmental Quality Analyst
U.S. Fish and Wildlife Service

Kathy Metcalf
Director, Maritime Affairs
Chamber of Shipping of America

Mike Ripley
Environmental Coordinator
Chippewa Ottawa Resource Authority

John L. Teem
Aquatic Nuisance Species Representative
National Aquaculture Association

Darci Vetter
Office of U.S. Trade Representative

Donna L. West
Senior Import Specialist
USDA APHIS

Alice Wywiałowski,
Policy Analyst
USDA APHIS

CHAPTER 1 – DESIGN VERSION 1

Phase 1: Assignment – 2002

The Invasive Species Pathways Work Team was established in June 2002 by the Invasive Species Advisory Committee to accomplish discreet tasks contained within the National Invasive Species Management Plan. Assignment scope extended to addressing issues related to unintentional introductions of invasive species, specifically addressing those action items numbered 16, 17, and 20, as directly recounted below:

16. Federal agencies will take the following steps to interdict pathways that are recognized as significant sources for the unintentional introduction of invasive species:

- a. By July 2001, NOAA, the Coast Guard, Interior, and EPA will sponsor research to develop new technologies for ballast water management, because the current method of ballast water management--ballast water exchange--is recognized as only an interim measure to address non-native species introductions.**
- b. By January 2002, the U.S. Coast Guard will issue standards for approval of ballast water management technologies, because actual deployment of new ballast water technologies on ships is contingent on a standard by which to judge their efficacy.**
- c. By January 2002, USDA will issue additional regulations to further reduce the risk of species introductions via solid wood packing materials.**

17. By January 2002, the Council will implement a process for identifying high priority invasive species that are likely to be introduced unintentionally, e.g., Mediterranean fruit fly and brown tree snake, and for which effective mitigation tools are needed.

20. By January 2003, the Council will implement a system for evaluating invasive species pathways and will issue a report identifying, describing in reasonable detail, and ranking those pathways that it believes are the most significant. The report will discuss the most useful tools, methods, and monitoring systems for identifying pathways, including emerging or changing pathways, and for intervening and stopping introductions most efficiently.

Agency collective experiences indicated the most effective method of preventing unintentional introduction of non-native species was through identifying the pathways by which they were introduced; with the need to develop environmentally sound methods to interdict introductions. Past experiences also indicated that some pathways are/were already known to be significant sources of invasive species. For example, ballast water is probably the largest single source of non-native species introductions into coastal and estuarine waters. Wood packing materials are a source of serious forest pests. As a first step in dealing with unintentional introductions, the Pathways Work Team was instructed to address these already known 'significant' pathways.

Phase 1: System Design - 2003

In response to these challenges, the Invasive Species Pathways Work Team convened and developed methods for stratifying and evaluating all pathways. This initial report was published on October 29, 2003 (see www.invasivespeciesinfo.gov postings) and was formally ratified by the National Invasive Species Council during FY 2004.

Specific principles guided risk assessment and analysis. It was believed that invasive species risk assessments should reflect the reality of U.S. commerce and ecosystems. Thus, since U.S. Government Agencies' regulatory decisions apply to a broad range of sometimes multiple receiving habitats or endpoints (that range from large continent to island environments) risk assessment could not singly focus on the conditions of the expected site of first arrival.

As such, the Pathways Work Team developed core values or operating norms that were to be imbued in the risk assessment portion of the guide. They are as follows:

- Methods and rationale to be transparent
- Work products are to be open to public review
- Methods to be expert reviewed via consensus evaluation
- Products should be valid and reliable, as is operationally feasible
- Methods will make use of expert opinion (qualitative) and incident datasets (quantitative) information
- Methods will address all phases of invasion including transport, establishment, spread and impact
- Assessments must recognize that species and ecosystems interact
- Circumstances of the potential invasion can give varying importance to species or ecosystem traits
- Methods must be able to capture the uncertainty and quality of data
- When assessment relies on expert opinion, assessment be clear about the basis of that reliance and 'expert' qualifications
- Methods must be realistic relative to available resources

It was also expressed that eventual policy decisions regarding pathway priority should meet the following considerations:

- Cost of actions should be weighed against benefits
- Actions should be proactive and take advantage of opportunities
- Special attention should be given to pathways that are not regulated
- Pathways should be re-evaluated periodically since risks associated with any particular pathway can change over time due to changes in magnitude (propagule pressure), changes in sending or receiving ecosystem(s) and other factors
- Pathway evaluation should be open and participatory; involving experts and stakeholders.
- Broad-based involvement gives greater credibility for the finished product

The Pathways Work Team also noted that it is important to prioritize preparation of risk assessments since pathways usually remain open until the risk assessment is concluded. Agencies should conduct risk assessments even if the NISC process of evaluating pathways is not complete.

It was also determined that developed criteria for assessing risk priority depended upon the probability or consequence of introduction. At a minimum, this portion of the assessment should include the factors below:

- Pathway magnitude (number of species, inoculation strength and frequency, diversity of species carried via pathway)
- Survivability or viability of organisms during transit
- Likelihood of pathway to transmit invasive species that are difficult to detect or manage during transit in the pathway

- Environmental comparability of origin and destination habitats
- Ease of spread (via artificial or natural means) once present (i.e., Does it have high reproductive rates? Is it highly mobile? Are there other factors that would facilitate its rapid spread)
- Difficulty of control if the species becomes established

Phase 1: Design 1 Report

In synopsis, the Pathways Work Team report of October 2003 presented three major products: (1) scientific and 'philosophical' concepts forming the basis to pathway rankings; (2) a pathway factors assessment tool; and (3) exemplar tree-diagrams or charts of pathway constructs (see Chapter 3 and Appendices G and H of this document for updated versions). It was determined at that point, due to limitations on available and accurate quantitative data, assessment would have to be based upon subjective, expert opinion, supported by existing literature and invasive-specific datasets. For risk assessments, it was deemed critical for pathway risk analysts to be able to attend to all relevant taxonomic groups; that jurisdiction was limited to human-assisted movement of organisms; and, that the instrument(s) should be sufficiently flexible to address local to national perspectives, as well as the full range of taxa and pathways. This 2003 report is available on www.invasivespeciesinfo.gov

Phase 2: Design 1 Field Test - 2005

On June 21-22, 2005, the National Invasive Species Council, Pathways Work Team sponsored an Invasive Species Pathways Focus Group Assessment Conference. The Conference was held at USDA APHIS, Oklahoma Memorial Conference Center, Riverdale, Maryland. The objectives of the conference were two-fold: (1) to provide an avenue for Federal, state, tribal governments, industry and academia to jointly analyze three specific pathways that unintentionally introduce invasive species into U.S. ecosystems and (2) to receive evaluative feedback on the validity and efficacy of proposed pathway risk assessment methodology and diagrams.

The following processes were used to achieve conference objectives: (1) convened expert focus groups comprised of government, industry and academic experts to qualitatively evaluate the invasive risk levels associated with air cargo, wood packing material and shipping industry/ballast water pathways (which would address such invasive species as brown tree snake, Asian longhorned beetle and zebra mussels); (2) assessed quantitative pathway risk analysis datasets; and (3) conducted a 'test' training session relevant to education of agency personnel on invasiveness species.

The anticipated outcomes from the conference included the following: (1) cross-agency and industry assessment of the threat of invasive species introduced via the specified pathways; (2) evaluation of the validity and efficacy of proposed pathway risk assessment methodologies; and, (3) recommendations on future training and prioritization efforts.

Conference planners intended that results would provide data and resultant analysis to agency decision makers to assist in collaborative efforts such as resource leveraging, targeting of invasive populations, and identification of gaps or inconsistencies between organizations that may inhibit efforts to prevent unintentional introduction of invasive species.

Phase 2: Design 1 Field Test Report

Feedback from these focus groups on the assessment tools, methods and outcomes was highly productive but nearly overwhelming as it forced the Pathways Work Team to reconstruct virtually all pathway assessment methods and tools. As such, activities were deemed successful, as they precluded the implementation of a product in need of significant revisions. A by-product of this

conference was the realization that the assessment tools and methods will be a continually evolving process; as sophistication of tools and supportive datasets improve.

There were a total of 42 conference attendees that participated in two evaluations: (1) critical assessment of pathway tools; and (2) evaluation of the process for administering the tools. Thirty-three participants provided written comments regarding the pathway criteria and ranking processes; thirteen provided feedback on conference processes.

Conclusions were, despite three separate work groups, nearly unanimous in suggested changes. Recommendations are provided below in synopsis format:

The Guide: Overall, the process and use of an assessment guide are supported. However, participants indicated that extensive revisions would be required. Revisions (as described below) fell into one of the 4 categories of: (a) assessment process; (b) assessment tool and questions; (3) diagrams; and (4) evaluation scales:

Assessment Process: It was the general consensus that the assessment tool should be completed by experts on an individual basis, then via focus group procedures. Revised methodology is contained in Chapter 3 of this report.

Assessment Tool: Numerous additions or changes were recommended for the assessment tool - - and were so extensive that field test evaluations of wood packing material, air transport and ballast water cannot be said to be reliable or valid assessments based on conference focus group assessments. This is not to indicate that expert assessments made of the pathways were invalid, just that the tools used must be significantly revised to ensure credibility, validity and reliability. The following is an overview of salient points:

- Specific invasive characteristics of a pathway's start, transition and endpoint(s) must be defined
- Geographic and eco-region issues are critical to assessments
- Questions must be reworded to current assessment, only
- Questions must contain more defined, specific language
- Duplication of similar questions must be avoided to preclude unfair weighting of instrument
- Uncertainty factors must be more thoroughly assessed
- Terms and definitions should be included or indicated as same as ISPM Glossary of Terms
- Scientific assessment is separate from policy, cost/benefit issues or action plans
- Pathway characteristics need to be defined and coupled with species-specific invasive qualities
- Evaluation should be done by a mix of experts
- Need more intensive instruction as to how to complete the tools

Diagrams

Suggestions for expanding the diagrams included the following pathways:

- military baggage and gear
- travelers (themselves)
- pets and animals for entertainment

- travel/tourism, cut flowers
- fruits and vegetable commodities
- domestic waste streams
- movement of raw logs within U.S.
- garbage transport
- recreational boats and vessels (T12.2)
- non-food aquaculture
- animal liberation

Evaluation Scales

- Rankings do not provide sufficient complexities for stratifying pathways
- Scale of severity needs to be established (i.e., what is high versus low)
- The average of categories doesn't give value. Need logistic regression analysis
- Clarification is needed on certainty/uncertainty issues
- Assessments must be accurate, reliable and predictive in orientation

The Pathways Work Team incorporated/amended all tools and methodologies relative to the above recommendations. However, some of the comments expressed needs that outstripped the current sophistication level of information gathering and management. These recommendations will not be overlooked or 'lost' but will have to be deferred to future revisions of the guide and the incorporation of mathematical algorithms or indices into database queries.

CHAPTER 2 - REDESIGN

Conceptual Framework: The underlying conceptual framework and issues posed to the Pathways Work Team group via focus group feedback was: How could NISC promote a methodology and infrastructure for cooperative management of invasive species pathways in a matrix-method that crossed Federal, state, tribal, local, academic and special interest group lines? Subsidiary to this issue was the development of a way to rank risk (i.e., scale of severity) or threat posed by a particular invasive. This determination would bring resolution (at best) or at minimum, prioritization, to competing interests as to which invasive(s) would pose the greatest consensus risk to the entire U.S. populace (i.e., not just a single stakeholder strata). In addition, the 'consensus on risk' had to ensure prioritization gave precedent to human health, economy and ecology issues, in respective order.

The work group early recognized that diligence in addressing scientific pathway identification and prioritizing issues are essential; as the ultimate outcome of all these recommendations - - namely the allocation and assignment of Federal resources and programmatic priorities - - was of great consequence to multiple stakeholders.

The national invasive species effort, in tandem with current trends of international collaboration and resource management, must fulfill the role of expert science in policy processes for multi-layered decision-making. The construct of pathway assessments, therefore, had to 'break new ground' in developing a methodology that was democratic, transparent, scientifically expert and yet geo-politically sensitive. The methodology had to be sufficiently flexible so that it could be used by various stakeholders on local, regional and national levels; while giving platform for cross-organizational forums for integrated action planning between those with shared national interests on a specific pathway. The end-goal is a full systems-approach to invasive species detection, management and mitigation.

Qualitative and Quantitative Assessment

The International Organization for Standardization defines risk as "the combination of the chance of an event and its consequences" (IOS, 2002). The Pathways Work Team made early agreement that pathway analysis and prioritization would parallel risk assessment (i.e., the scientific evaluation of the biological risks and potential consequences) procedures. In addition, it was decided that questions regarding risk management (i.e., a process of determining appropriate measures to reduce risk) would also be included in assessment data as reduction of risk practices directly impact severity of pathway invasiveness. Ultimately, it was decided that pathway prioritization and analysis was so broad in scope, it would require both quantitative and qualitative methods to give the most accurate assessment based on existing information and expertise.

Qualitative Assessment - The Proposed Process and Tools: As delineated in the opening remarks made by Hilda Diazo-Soltero, USDA Invasive Species Liaison, the purpose of the June 21-22, 2005, Invasive Species Pathways conference was to trial test the process and instruments developed for assessment of national pathways. The processes and tools (recounted below) was the Pathways Work Team's best attempt at creating a democratic, scientific policy process that utilizes the best practices for qualitative and quantitative assessments; accommodating multi-layered factors and perspectives. Components of the process are further elucidated below:²

² See *User-Friendly Handbook for Project Evaluation* (NSF 93-152) as paraphrased and applied to remainder of section.

Stage 1: Individual Expert Qualitative Review. Initially, individual experts gathered and codified their first-hand information and expertise relative to a specific pathway. In their assessments, the experts openly explored pathway nuances germane to their working environment and orientation. In addition, these experts developed a pathway prioritization based on a ‘full system’ (i.e., full pathway cycle) context. This was particularly important as pathways are viewed as a series of events that may lead to the introduction of an invasive species. The first step of the method (i.e., individual participants first completing the assessment tool, independently) ensured that evaluators adequately represent their particular stakeholder group’s perspectives and issues. (This approach is only effective if participants are well-qualified, content experts.) The questions contained in the assessment tool provided a structured protocol to guide individuals to make thorough observations via a set of targeted concepts and criteria that would be later used for consensus assessment.

Stage 2: Group Expert (Consensus) Qualitative Review. The second stage of evaluation was accomplished by a pathway-specific focus group of experts that represented pathway-specific stakeholder groups. Expert determination was based on professional credentials, organizational liaisons, work history and academic credentials. These focus group reviews, in themselves, provided very different data from individual assessments. They enabled the capturing of multiple consensus perspectives of various stakeholders; creating a common vision or analysis of a specific pathway. This enabled identification of common aspects of a pathway while setting a group forum for addressing related issues.

The pathway focus groups combined elements of both interview and participant observation; while capitalizing on collective group intelligence. Group interaction generated data and insights that most likely would not have emerged through individual evaluation.

Based on conference outcomes, the Pathways Work Team recommends focus groups be limited to 8 to 12 persons; be managed by facilitator; and have a designated official recorder. This meeting format not only is conducive to reviewing the efficacy of the assessment tools and efficacy of quantitative datasets; but is conducive towards the emergence of new ideas.

Guiding the Focus Groups. A challenge for these focus group proceedings was the gleaming of usable, consistent, descriptive statistics for cross-organization and pathway comparison. The assessment tool served as a topic guide to assist focus group facilitators in keeping various perspectives on a unified track. The tool also served as a road map in developing the joint findings and the final report.

Focus Group Facilitation. Focus group participants were asked to reflect on the questions asked by the moderator; were permitted to hear one another’s individual responses and then make additional comments beyond their own original responses. It was neither necessary to reach consensus nor to resolve disagreements as this effort was a ‘field test’ of the tools. The facilitators kept the discussion flowing and ensured that no one or more persons dominated the discussion.³ in the future, however, the facilitator(s)’ role will be to seek

³ *User-Friendly Handbook for Project Evaluation* (NSF 93-152).

consensus between participants on pathway risk prioritization (see Chapter 3 of this guide).

Focus Group Construct. It was decided that one group per pathway was essential due to pathway complexities and the subsequent varied expertise required. Though a good rule is to conduct at least two focus groups per pathway to ensure response validity; in that pathways are limited in scope (i.e., a pathway can be succinctly defined and assessed) single focus group assessment were/are deemed sufficient. (This is not to say once evaluated, always evaluated. In fact, it is expected that pathways will be re-assessed, as needed, due to changing conditions.)

Recording Focus Group Data. The procedures for recording focus group sessions were basic. The focus group facilitator was assigned a non-expert person designated as the recorder to take notes on both comments and assessments. A major advantage to this is the recorder focuses on observing and taking notes, while the facilitator concentrates on asking questions, facilitating group interaction, following up on ideas, and making smooth transition from issue to issue. It was understood that these results would be codified in a final report but without individual names or organizations attributed to specific comments.⁴ (Feedback from conference attendees on use of facilitators/recorders was assessed as highly favorable per a separate evaluative survey).

Other Qualitative Methods - -Document Studies. Though quantitative benchmarks/datasets were researched to assist pathway prioritization, a significant lack of data history caused use of one other method for pathway assessment - - document and scientific studies. Pathway-specific documents were supplied to participants several weeks prior to the conference to provide exemplar pathway cases and to create a common knowledge base for discussion and comparison. Successful, the Pathways Work Team encourages the augmentation of qualitative and quantitative datasets with document studies for all future pathway assessments.

⁴ *User-Friendly Handbook for Project Evaluation* (NSF 93-152).

Quantitative

The goal of developing quantitative datasets is to give statistical indicators to aid in assessing the likelihood of invasive species entry or occurrence, establishment or spread of a pest or disease within the territory, phytosanitary measures which might be applied, and the associated potential biological and economic consequences or the evaluation of the potential for adverse effects on human or animal health. Assessment should first be rooted in the unmitigated (unmanaged) pest or disease risk but then modified to address mitigation/management practices. Biological, economic or ecosystem consequences should also be addressed, but in terms of merging risk 'science' with policy decisions.

Specific risk factors for quantitative assessment included such factors as the following

- Prevalence of a pest or disease agent in the exporting area
- Geographic and environmental characteristics;
- Sanitary and phytosanitary status of the adjoining or neighboring areas
- Trading partners and practices
- Regulatory infrastructure of the exporting country
- Invasive species surveillance and monitoring system(s)
- Pest or disease agent survival rate in transit
- Interception data
- Invasive species destination risk factors such as likelihood and consequences of a particular pest or disease agent surviving, multiplying, establishing and spreading in the territory of the importing country
- Uncertainty about the organisms, the human error factor, or methods used
- Distribution of the commodity or vectoring agents
- Availability of susceptible hosts and/or competent vectors

The relevant economic factors include:

- The potential damage due to loss of production or sales in the event of the entry, establishment or spread of a pest or disease
- The cost of control and eradication
- The relative cost-effectiveness of risk mitigation strategies
- Cost-benefit analysis of mitigation versus consequence of introduction

As previously indicated, quantitative data was unavailable, sporadic or incomplete. The Pathways Work Team could not, therefore, statistically define acceptable levels of risk but rather had to create evaluative scales of relative risk for pathway analysis. The Team recommended a special work group to be convened to develop statistical indices at a later date.

Qualitative vs. Quantitative: The Search for Reliable Data

The qualitative approach primarily uses categorical values for inputs and outputs. The input variables were then assigned a particular ranking such as low, moderate, or high risk. The Team also found that due to a lack of valid, consistent datasets, pathway analysis would have to rely more heavily upon qualitative (i.e., expert) opinion. It is anticipated as data collection and predictive indices increase in sophistication, there will be a shift towards more quantitative analysis - -but this shift will only result after several edifications or 'design evolvments' of this process. The complexities yet potential benefits expressed by participants regarding quantitative assessments were extensive and call for future

statistics-based program development. The section below, written by Laura Biven, (PhD, Applied Mathematics, Advisor to Pathways Work Team) elucidates these future challenges. The Team welcomes comments, feedback and discussion on the concepts posed in the paper, below.

In Search of an Objective Measure of Pathway Risk

Any risk assessment process has two key components 1) identifying a projected outcome and 2) assessing the likelihood of that outcome being realized. In the case of assessing the risk posed by potential invasive species, this can be broken down further into the following three components:

- 1) *The likelihood of introduction*
- 2) *The likelihood of establishment*
- 3) *The magnitude of damage*

The likelihood of introduction can be quantified for a particular species and well defined pathway. This measure can be objective in so far as the total likelihood is based on the individual probabilities that the species follows each stage of the pathway. The caveat is that it is the risk assessor who identifies the various stages and assigns their relative importance. Errors in this measure (and they may be considerable) are mostly due to the lack of accurate information about the various stages of the pathway (e.g., infection rates; likelihood of incidental infestations of cargo; efficacy of natural and artificial mitigations, etc).

The likelihood of establishment can be estimated for a particular species and target habitat. Estimates are usually semi-quantitative (high, medium or low) and are inaccurate, not for lack of information, but because the establishment of a species is critically dependent on a large and unknown set of variables. Starlings, for instance, were introduced into Central Park in New York City eight times. Only two of these populations established.¹

The magnitude of damage resulting from the establishment of a particular species can be assessed by considering each affected commodity (e.g., the environment; human or animal populations; agricultural crops, etc). These estimates are often quantified as dollar amounts but are nonetheless inherently subjective or, at least, dependent on cultural values. It is the risk assessor or community that decides how to assess the relative value of human health and freedom from trade barriers, for example. Expressing these values as dollar amounts is simply a useful tool for recording these decisions.

Objectivity is a Question of Detail

In searching for an objective measure of pathway risk, we must content ourselves with objective measures of 1 and 2: the likelihoods of introduction and establishment. It's worth noting that objectivity of these measures does not imply that the measures must be quantitative and, conversely, a quantitative measure is not necessarily objective. Indeed, it is relatively unimportant whether the measure is quantitative or qualitative. Of much more importance is the accuracy of the information on which the assessment is based.

All of the steps for assessing the risk of invasive species, above, place strict requirements on the level of detail needed in the definition of species and pathway (including pathway origin and target habitat). It is unrealistic, however, to perform risk assessments on all species/pathway combinations on a national scale. For this reason, the Pathways Work Team has defined a number of pathway categories (these are referred to as "pathways" although may be better thought of as collections of pathways or pathway categories).² The task of assessing the risk of pathway categories necessarily has two levels of detail: The first is the level of detail required to accurately assess risk as outlined in the steps 1—3 above. The second is the more general level on which pathway categories are defined.

Any assignment of risk to a category of pathway is necessarily a summary of the underlying specific species/ pathway risks. The summary may be the mean risk of the group or the maximum risk value or some other summarizing measure. Any summary, however, constitutes a loss of information. The mean value can mask high risk elements in the group whereas the maximum risk value loses information about the absolute potential for damage. Sensitivity analyses of the risk of particular species/ pathway combinations show that the value of risk depends critically on the details of the target habitat, season of introduction, species type, etc. The value of risk for two elements in the same category are almost surely unrelated, therefore. This lack of correlation among elements in the pathway category furthers the argument against assigning a single value of risk to the category.

When considering a pathway category, there are two possibilities for the available data:

- I. Data exist (quantitative or qualitative) about specific species, pathways, origins, target habitats or combinations of these. Perhaps a pest risk assessment has been done for a particular species/ pathway combination that falls under this category. Perhaps there is only anecdotal evidence of a particular species entering via the pathway. In any case, the information will be about specific elements of the pathway category under consideration. Information of this type can be relevant for assessing the likelihood of introduction and/or the likelihood of establishment.
- II. No such data exist or are available. Perhaps the pathway has never before been studied or no reliable conclusions have resulted from the study. In this case, assessment of the likelihood of introduction without further analysis is largely guesswork. Assessing the likelihood of establishment, given the introduction of a particular species, may be estimated with a predictive screening method with full understanding of the limitations of these methods.

Methods for Assessing Likelihood

Assessing the likelihood of introducing a species differs depending on the details of the species and pathway in consideration. The method of diagramming the pathway and assessing the probability that some number of individuals of the species survives each stage of the pathway is well documented.³

Assessing the likelihood of establishment is a difficult task and many different approaches are possible, each with their pros and cons and underlying assumptions. What follows are evaluations of a selection of the methods available.

- *Gather of information about known species present in the pathway.* There are many (although insufficient) web accessible databases which contain information about invasive species; possible invasives; their modes of entry and spread in the US; their native habitats and means of reproduction.⁴ Most of these databases deal with plant species.
- *Calculation of the overall flux of species through the pathway per year or per transport event.* Under the assumption that the number of invasive species present in a pathway is directly related to the total number of species in the pathway, this is one way to estimate the number of invasive species present in the pathway. Finding the data to perform this calculation may be difficult and incur large errors. Comparing pathways based on this measure is meaningless unless the species under consideration are similar.
- *Use of Predictive Screening Methods to Assess Invasiveness of Species.* Under the assumption that particular characteristics of a species can determine its likelihood to be invasive, there are a number of models which seek to identify these characteristics for a narrow enough class of species. The invasiveness of the genus *Pinus* in North America has been linked to characteristics of mean seed mass and minimum juvenile period, for example⁵. These methods tend to develop cautious criteria. The emphasis is on correctly diagnosing a species as invasive while some non-invasives may be misdiagnosed as invasive. The only criterion consistently linked with invasiveness of plant species and broadly accepted in the professional communities is whether or not the species is invasive in any other environment.
- *Use of Predictive Screening Methods to Assess Invasibility of Habitats.* Similar predictive screening models exist to predict the likelihood of certain ecosystems being invaded by non-native species, usually plants. Disturbed ecosystems have been associated with invasibility, for example.⁶ These models are not uniformly accepted in detail although the premise that an ecosystem may be more or less inherently vulnerable to invasions has broad consensus support.

- *Notes on the use of the Survey:* The survey developed by the Pathways Work Team solicits justified (through citations in the literature, first hand accounts etc.) expert opinion. Results from individual surveys are essentially subjective. Results from a collection of surveys depend on the variety and number of experts participating as well as the breadth of their collective and individual expertise. There is some reason to believe, however, that the spectrum of information gleaned from a large and diverse enough group of experts is objective in the sense that it is reproducible—the results from a different but similar group of experts would extract the same information. More tests with this tool need to be completed to support this belief, however.

Pathway Risk Assessment Do's and Don'ts

DO NOT summarize risk information about individual species/pathway combinations to assign a single numeric value of risk to a pathway category. Some synthesis of this information is necessary to compare the relative importance of pathway categories, but this process cannot be formulaic and is necessarily subjective.

DO look at information about individual species and pathways in the category and determine the quality of the information source (published records, informed opinion, anecdote, etc.)

DO Use predictive screening where possible but only with a full understanding of the assumptions involved and quality of data used.

¹ See the review article “Reducing the risks of nonindigenous species introduction” by Jennifer L. Ruesink and Ingrid M. Parker, *Bioscience*, Vo. 45 Issues 7, p. 465 (Jul/Aug 1995) which cites Phillips, J.C. “Wild birds introduced or transplanted in North America” *USDA Technical Bulletin* No. 61. US Department of Agriculture (1928)

² See Pathways Diagrams in Report Appendices.

³ See, for example, “Guidelines for Pathway-Initiated Pest Risk Assessments” .US Department of Agriculture, APHIS, PPQ. (October 17, 2000)

⁴ A comprehensive list is contained in “Invasive Species Databases—Proceedings of a Workshop” Charles Valentine Riley Memorial Foundation, 1999. See also <http://www.nbj.gov/search/sitemap.html>

⁵ Rejmánek, M. and Richardson, D.M. “What Attributes Make Some Plant Species More Invasive?” *Ecology*, 77(6) (1996) pp. 1655-1661. See also Reichard, S.H. and Hamilton, C.W. “Predicting Invasions of Woody Plants Introduced into North America” *Conservation Biology*, Vol. 11 No. 1 (1997) pp. 193-203

⁶ See Rejmánek, M., Richardson, D.M. and Pyšek, P. “Plant Invasions and Invasibility of Plant Communities” in

Managing Uncertainty

Reduction of uncertainty has always been the central goal of any scientific effort. Uncertainty may result from a range of issues such as follow:

- flaws in methodology (i.e., measurement errors or lack of knowledge of the steps or elements of risk evaluation);
- lack of expertise, coherence or error on part of risk assessor, biological unknowns of the invasive organisms/pathways;
- insufficient information (i.e., lack of accurate/precise knowledge of the input values); or
- political impediments.

What is critical to realize is that uncertainty need not be an impediment to resolution of an issue. The risk perspectives developed are based upon the state of scientific understanding of the pathway at a particular time - - and reflect a state of confidence in that understanding. Culture, organization, educative norms or values may directly impact the level of uncertainty a risk assessor may experience, but the process for pathway risk analysis must ‘overcome’ these obstacles to create action.

As such, the Pathways Work Team decided the assessment process must characterize the nature of uncertainty each assessor may have (on a per question basis) with a requirement for assessors to devise a strategy to either reduce the uncertainty associated with the question, or a method to assess the pathway, with acceptable levels of uncertainty tolerated.

It is anticipated that individual uncertainty issues will be minimized or ameliorated through the secondary, consensus process whereby broader range (e.g., group) expertise, experience and knowledge will be incorporated into final factor assessment. It is understood that group expertise will replace individual uncertainty factors; and that if there is general consensus of uncertainty on a particular risk factor, the group may elect to raise or lower the risk 'score' of a pathway based upon extrapolated reasoning. Risk assessment is not an absolute, but a relative 'equation'.

Pathway analysis is in a sense, a way of democratizing science; as the end goals are transparency, attention to specific scientific and technological outputs and development of human socio-political (i.e., government) structures. The processes devised must be rigorous, relevant and participatory. It is important evaluators accept that most important decisions are made with a degree of uncertainty; but actions in light of uncertainty are justified by a high level of commitment to set goals, values and actions. Policy decisions are based on what the future should look like for particular groups with an underlying acknowledgement that realities may modify those future goals. Policy sets the direction to take, but science creates and maintains the focus.⁵

⁵ Source: Arizona State University Consortium for Science, Policy and Outcomes, College of Liberal Arts and Sciences

CHAPTER 3 – THE GUIDE VERSION 2

The Redesign

The focus groups called for considerable restructuring of the pathway assessment tool. What was recommended was the need to develop a three-tiered methodology that adequately addressed policy direction, risk science and interagency action planning. This methodology had to ensure that the priorities of first, human health, second economy, and then ecology (as defined in National Invasive Species Management Plan) were accommodated.

Within the above recommended framework, the focus groups challenged the Pathways Work Team to also devise a method to determine which individual pathway(s) to first assess. There were concerns over unknown pathways; false perceptions over severity or ‘innocuous’ nature of pathways; or that the current instrument would result in little differentiation over pathway risk. As such, and after great discussion on weighting particular factors and creating scales of severity, the following phased assessment is proposed. This method has not been tested via focus groups and should be trial tested with appropriate revisions prior to full implementation.

Pathway Evaluators: As defined previously, pathway prioritization is matter for program experts. It is important to gather together a team of individuals who can appropriately accomplish all tasks below. At a minimum, a pathway assessment expert team list should be compiled that includes information as to the experts’ name, organization/associations, areas of specialty, published papers, academic background, related work history and contact information.

The segment of this report that serves as an instructional guide to pathway definition and prioritization begins on the next page for ease of use (i.e., removal from) the remainder of the conference report.

Stage I: Multiple Pathway Triage

An initial question arose: How should agencies determine which pathway should first be evaluated? What appeared to be a simple question was in actuality, a complicated one, expressing the need for a preliminary triage approach to pathway prioritization. Restated, stakeholders asked the following:

“How do we prioritize resources dedicated to the evaluation of invasive species in light of multiple competing pathway interests and yet to be determined pathway risk levels?”

The Pathways Work Team strongly felt that triage should be directly relevant to agency mission and strategic priorities. Therefore at Stage 1, an agency-based group of two or more invasive species ‘generalists’ are asked to convene to conduct the following preliminary evaluation:

Triage Process

Step 1: Review the inventory list/diagrams of all invasive species pathways; adding any pathways to the list that may be undefined (see Appendix G for list). Briefly define the pathway particulars (i.e., start point, endpoint, transitions, any materials, agents, etc., that could vector invasives).

Step 2: Define agency mission, functions and responsibilities relative to invasive species pathways

Step 3: Select and list all pathways that are pertinent to the agency’s mission

Step 4: Indicate, briefly, what particular invasives are associated with each pathway. A list of potential invasive species categories is provided below:

- All hitchhiking organisms
- All aquatic organisms
- Fouling organisms (e.g., organisms that attach to boats, pilings, platforms, etc.)
- Arthropods (e.g., insects, arachnids, crustaceans, etc.)
- Mollusks (e.g., giant African snails, zebra mussels, etc.)
- Plants and plant propagules (e.g., water hyacinth, Russian knapweed, etc.)
- Plant pathogens (e.g., sudden oak death, etc.)
- Phytoplankton (e.g., Amphidinium, dinoflagellates, etc.)
- Vertebrates (e.g., snakeheads, gavials, rats, brown tree snakes, etc.)
- Human and animal parasites (e.g., liver flukes, etc.)
- Human and animal pathogens (e.g., salmonella, West Nile virus, foot and mouth disease, SARS, etc.)

Step 5: Assign each listed pathway to a threat level. The threat levels are defined as:

Threat Level A - - the pathway currently transmits an invasive species that poses a direct threat to human health

Threat Level B - - the pathway currently transmits an invasive species that poses a direct threat to economic systems

Threat Level C - - the pathway currently transmits an invasive species that poses a direct threat to ecological climates.

Note: By definition, an invasive species must fall within one of the above three categories. New species or exotics are continually entering the country via these selfsame pathways. But if they do not pose a threat, they do not meet the definition of invasive, for these purposes.

Though some pathways may pose more than one level of threat, this is a rough cut hierarchical assessment and therefore only one value, the most pernicious (i.e., human health, then economy, and finally ecology) may be assigned. As a frame of reference, ballast water carrying cholera that dumps directly into drinking water would be a threat level of A. Whereas that same water, if dumped into a stream that is not used for any human or business purposes (i.e., where cholera contamination would not impact health or economics), then the threat level could be C - - or could even possibly result in the determination that in the particular circumstance (or receiving point), it would not even be considered invasive.

Triage Process Chart

1.Pathway Name	2. Agency Mission & Functions	3. Mission Related IS Pathways & Description	4. Invasive Transmitted via Pathway	5. Threat Level
T 1 Transportation T1.1 Air T1.2 Water, Aquatic T1.2.1 Ballast Water T1.2.2 Hull/Surface T1/2.3 Stowaways T1.2.4 Superstructures T1.2.5 Transportation Relocation of Dredge	U.S. Coast Guard protects the public, environment & U.S. economic interests in ports, waterways, along the coast, on international waters, or in any maritime region	T1.2.1 Ship Ballast Water- Cargo ship that begins voyage in Kusadasi, with endpoint NYC.	Amphidinium Cholera	A (Human Health First Priority)
		T1.2.2 Hull/Surface Fouling. Cruise ship start point Miami, to Jamaica and Return	Zebra Mussels	B (Economy Second Priority)
		T1.2.5 Dredge Relocation Barge traveling from Hawaii to Oregon	Water hyacinth	C (Ecology Third priority)

(Note: this is only an example and does not reflect full or accurate range of invasive species or pathway analysis for U.S. Coast Guard).

The result of this triage is a prioritized list to determine which pathways to first assess. In this case, ship ballast water is first, followed by hull fouling, then dredge relocation.

Stage II: Single Pathway Risk Assessment (By Individual then Focus Group Review)

There are four steps to Single Pathway Risk Assessment: (1) pathway definition, (2) pathway scope; (3) pathway risk level; (4) pathway risk score.

[The steps contained in Stages II and III are to first be completed by individual experts, independently. These independent assessments are then to be used by the experts as background information for completion of a single focus group consensus decision for Stages II and III.]

1) Step 1: Indepth Pathway Definition. At this stage, it is critical to DEFINE, not analyze, the characteristics of the pathway. Pathway definition includes the following:

- a) Define the start point of the pathway, including all physical, geographical, ecological, etc., characteristics relevant to pathway invasiveness (i.e., ship starting at shipyard loading dock in Charleston, North Carolina where wood packing material originating from the U.S. is being used to transport motor parts).
- b) Define any intermediary stop points (i.e., ship docks in New York City but crates remain on hold. Ship then travels to Miami, Florida)
- c) Define endpoint of the pathway (i.e., crates are off-loaded at Miami port. Wood packing material is destroyed via wood chipper and motor parts distributed via truck to local stores).
- d) Specifically define all invasives may be considered for pathway analysis. These include invasives from the following exemplar categories:
 - i) All hitchhiking organisms
 - ii) All aquatic organisms
 - iii) Fouling organisms (e.g., organisms that attach to boats, pilings, platforms, etc.)
 - iv) Arthropods (e.g., insects, arachnids, crustaceans, etc.)
 - v) Mollusks (e.g., giant African snails, zebra mussels, etc.)
 - vi) Plants and plant propagules (e.g., water hyacinth, Russian knapweed, etc.)
 - vii) Plant pathogens (e.g., sudden oak death, etc.)
 - viii) Phytoplankton (e.g., Amphidinium, dinoflagellates, etc.)
 - ix) Vertebrates (e.g., snakeheads, gavials, rats, brown tree snakes, etc.)
 - x) Human and animal parasites (e.g., liver flukes, etc.)
 - xi) Human and animal pathogens (e.g., salmonella, West Nile virus, foot and mouth disease, SARS, etc.)

Pathway definitions should be brief, narratives or lists that give succinct facts (not opinion) regarding pathway characteristics. Defined characteristics for this pathway are:

Pathway Title _____ **(Description Follows)** _____

2) Step 2: Pathway Scope Determination

The next step is to define the scope of the pathway. The underlying assumption for this factor for prioritizing pathways is: the broader the pathway (i.e., in terms of distance and ecoregions potentially contaminated), the greater the threat the pathway may pose. These categories are not absolutes but represent a general framework for scope determinations. Individual expertise, knowledge and discretion should be used in assigning scope level. There may be nuances regarding a particular invasive species or pathway that will warrant varying the scope category as defined. Ecoregion determinations, ultimately, are the responsibility of the assessing team. Specific pathways and associated invasive species may even call for redefinition of ecoregions. Any redefinition should be documented to provide basis for transparency in decision making. Assign the pathway scope using one of the following categories:

Level 0 - Single Event. This is an internal state outbreak with no movement of invasives via a pathway.

Level I - Interstate (i.e., pathway crosses a state line) with invasive pathway movement across one or more ecoregions within a single state or movement between two state boundaries.

II Level - Regional (i.e., multi-interstate pathway) with invasive movement across two or more ecoregions and three or more state boundaries.

Level III - Multiregional - - invasive pathway movement across four or more ecoregions or between two or more regional boundaries.

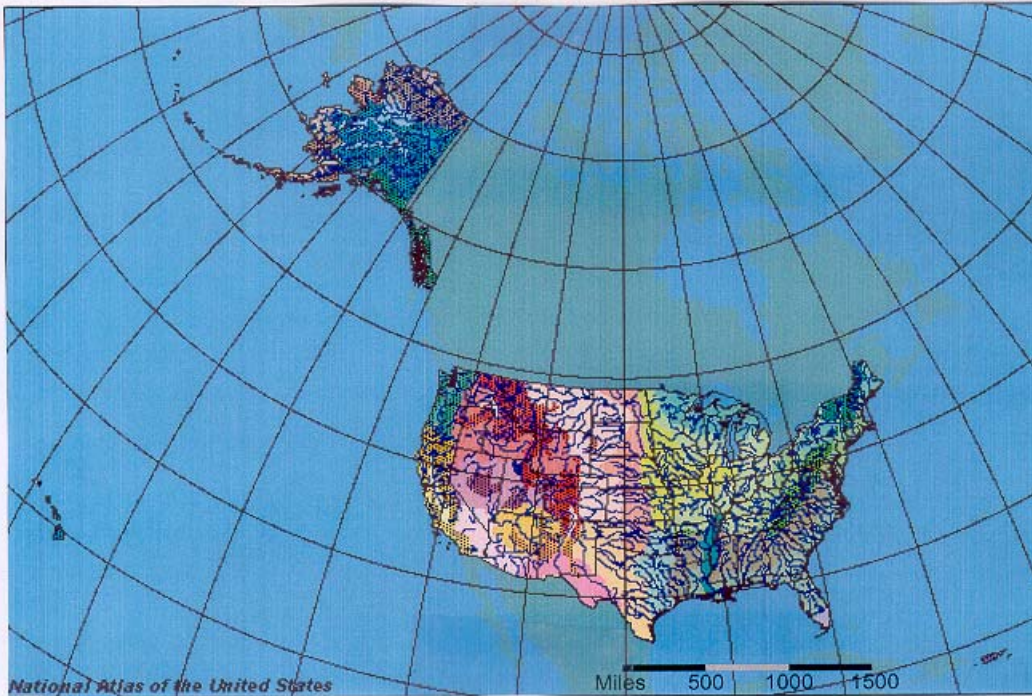
Level IV - National - - invasive pathway movement across five or more ecoregions or between three or more regional boundaries

Level V - International - - invasive pathway movement between the U.S., its territories and foreign countries. This pathway may range from single start and endpoint, to multiple 'stop points' of pathway from initial to final destination.

Assigned Pathway Scope Level: _____. Comments or rationale for pathway scope decision:

*For the purposes of example and reference
The Pathways Work Team has provided
the following graphic depiction of
pathway related ecoregions produced by
U.S. Geological Survey, www.nationalatlas.gov*

Invasive Species Pathway Scope Ecoregion Map



- POLAR DOMAIN**
- Tundra Division
 - Arctic Tundra Province
 - Bering Tundra (Northern) Province
 - Bering Tundra (Southern) Province
- Tundra Division - Mountain Provinces
 - Brooks Range Tundra-Polar Desert Province
 - Severe Perennial Tundra-Meadow Province
 - Alaskan Mountains Tundra-Meadow Province
 - Alaskan Oceanic Meadow-Heath Province
- Subarctic Division
 - Yukon-Interior Plateau-Taiga Forest
 - Coastal Trough-Humid Taiga Province
 - Upper-Yukon Taiga Province
- Subarctic Division - Mountain Provinces
 - Yukon-Interior Plateau-Taiga-Meadow Province
 - Alaska Range-Humid Taiga-Tundra-Meadow
 - Upper-Yukon Taiga-Meadow Province
- HUMID TEMPERATE DOMAIN**
- Warm Continental Division
 - Laurentian Mixed Forest Province
- Warm Continental Division - Mountain Provinces
 - Adirondack-New England Mixed Forest-Continental Forest-Alpine Meadow Province
- Hot Continental Division
 - Eastern Broadleaf Forest (Oceanic) Province
 - Eastern Broadleaf Forest (Continental) Province
- Hot Continental Division - Mountain Provinces
 - Central Appalachian Broadleaf Forest-Continental Forest-Meadow Province
 - Ozark Broadleaf Forest-Meadow Province
- Subtropical Division
 - Southeastern Mixed Forest Province
 - Coastal Plain Mixed Forest Province
 - Lower Mississippi Riverine Forest Province
- Subtropical Division - Mountain Provinces
 - Diabola Mixed Forest-Meadow Province
- Maine Division
 - Pacific Lowland Mixed Forest Province
- Maine Division - Mountain Provinces
 - Cascade Mixed Forest-Continental Forest-Alpine Meadow Province
 - Pacific Coastal Mountain Forest-Meadow Province
 - Pacific Gulf Coastal Forest-Meadow Province
- Prairie Division
 - Prairie Parkland (Temperate) Province
 - Prairie Parkland (Subtropical) Province
- Mediterranean Division
 - California Coastal Chaparral Forest and Shrub Province
 - California Dry Steppe Province
 - California Coastal Steppe, Mixed Forest, and Redwood Forest Province
- Mediterranean Division - Mountain Provinces
 - Sierra Steppe-Mixed Forest-Continental Forest-Alpine Meadow Province
 - California Coastal Range Open Woodland-Shrub-Continental Forest-Meadow Province
- DRY DOMAIN**
- Tropical/Subtropical Steppe Division
 - Great Plains Steppe and Shrub Province
 - Colorado Plateau Semidesert Province
 - Southern Plateau and Plains Dry Steppe and Shrub Province
- Tropical/Subtropical Steppe Division - Mountain Provinces
 - Arizona-New Mexico Mountains Semidesert-Woodland-Continental Forest-Alpine Meadow Province
- Tropical/Subtropical Desert Division
 - Chihuahuan Semidesert Province
 - Archaean Semidesert and Desert Province
- Temperate Steppe Division
 - Great Plains-Palouse Dry Steppe Province
 - Great Plains Steppe Province
- Temperate Steppe Division - Mountain Provinces
 - Southern Rocky Mountain Steppes-Open Woodland-Continental Forest-Alpine Meadow Province
 - Midline Rocky Mountain Steppes-Continental Forest-Alpine Meadow Province
 - Northern Rocky Mountain Forest-Steppe-Continental Forest-Alpine Meadow Province
 - Black Hills Continental Forest Province
- Temperate Desert Division
 - Intermountain Semidesert and Desert Province
 - Intermountain Semidesert Province
- Temperate Desert Division - Mountain Provinces
 - Nevada-Utah Mountains Semidesert-Continental Forest-Alpine Meadow Province
- HUMID TROPICAL DOMAIN**
- Savanna Division
 - Evangeliad Province
- Savanna Division - Mountain Provinces
 - Puerto Rico Province
- Rainforest Division - Mountain Provinces
 - Hawaiian Islands Province
- Mountains with altitudinal zonation. These provinces are named for the spectrum of zones from lower to upper (boreal), e.g. semi-desert-continental forest-alpine meadow

Level 0. Single Event. This is an internal state outbreak with no movement of invasives via a pathway.

Level I. Interstate (i.e., pathway crosses a state line) with invasive pathway movement across one or more ecoregions within a single state or movement between two state boundaries.

Level II. Regional (i.e., multi-interstate pathway) with invasive movement across two or more ecoregions and three or more state boundaries.

Level III. Multiregional - - invasive pathway movement across four or more ecoregions or between two or more regional boundaries.

Level IV. National - - invasive pathway movement across five or more ecoregions or between three or more regional boundaries

Level V. International - - invasive pathway movement between U.S., its territories and foreign countries. This pathway may range from single start and endpoint, to multiple 'stop points' of pathway from initial to final destination.

3) Step 3: Pathway Risk Level Analysis (Question-Based)

Step 3 is the portion of pathway assessment where risk experts form a science-based decision regarding the risks posed by a pathway. This assessment represents the ‘third cut’ in prioritizing pathways. Expert opinions are to be supported by quantitative datasets, expert literature and scientific expertise. Pathway complexities and characteristics are in constant change and flux - motivated by shifting trade and market patterns. As such, though future pathway risk assessments will strive for greater quantifiable or formulaic assessments, expert opinion will remain the key source of pathway risk determinations. Risk decisions are guided by response to the following set of pre-determined analysis questions.

Uncertainty Factor. During this process, evaluators must accept the existence of varying degrees of uncertainty. It is expected for all reviewers, even in light of the uncertainty, to come to a single/consensus whole number score for each question. If uncertainty exists, the basis for that uncertainty must be defined. Pathway analysts must give character to the uncertainty, using such rationale as exemplified below:

Uncertainty exists due to:

- flaws in methodology (i.e., measurement errors or lack of knowledge of the steps or elements of risk evaluation)
- lack of expertise, coherence or error on part of risk assessor, biological unknowns of the invasive organisms/pathways
- insufficient information (i.e., lack of accurate or precise knowledge of the input values), or
- political impediments

Each question (again, a single/consensus response in whole numbers) must be answered. The questions are geared to address such issues as probability of introduction, probability of establishment, history of invasiveness, available mitigation methods and invasive impacts. Issues regarding action planning, policy and political implications for the invasives are not part of this scientific risk assessment phase but rather will be covered in the last portion, Invasive Species response, action planning and communication efforts.

The segment of this chapter that serves as guided questions for pathways risk analysis begins on the next page for ease of use.

Question 1: What is the pathway’s history for frequency of introducing invasive species? (*Frame of Reference: Extremely High frequency ranking is defined, in relative terms, as introducing invasives that have had either human health pandemic implications, have caused serious economic impacts on major industries or have introduced invasives that negatively impacted numerous ecological niches.*)

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 2: What level (0-5) of viable invasive species does this pathway transport? (*Frame of Reference: Extremely High (i.e., ranking of 5) infers a pathway capable of transferring 100 or more viable invasives species in a single event.*)

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 3: What level (0-5) quantifies the number of viable specimens per invasive species transmitted via that pathway? (*Frame of Reference: Extremely High infers the pathway transmits numerous [i.e. 100 plus) viable populations that can readily be established. Extremely low infers that only 1-2 specimens capable of establishment/reproduction are transmitted.*

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 4: Based on the specific invasive species transmitted via this pathway, what is the relative level of risk (0-5) of establishment based upon the receiving endpoint (s) of the pathway (i.e., does the pathway introduce organisms into hospitable environments? (*Frame of Reference: A rating of 0 indicates the environment does not permit any establishment of the invasive species. A rating of 5 indicates the environment is a perfect match for the invasive species' natural habitat with plentiful food sources and no natural predators or ecosystem controls).*

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 5: What is level or amount of invasive species environments harbored by the pathway that would enhance viability of and opportunity for transmission of invasive species? (*Frame of Reference: Is there pathway substrate, trade material, or cargo? Does this volume represent high/ medium low levels of incoming material for the pathway assessed?*)

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 6: What is the level of invasive opportunities (1-5) posed by this pathway due to the number of potential invasive species entry points (i.e., single or multiple destination/transfer points)? (*Frame of Reference: A level 5 ranking infers multiple entry points (4 or more) that expand across the entire nation; whereas a level 1 assessment infers single, localized entry point with minimal opportunity for invasion*)

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 7: How hospitable to invasive organisms is the pathway? (*Frame of Reference: A rating of zero (0) means all invasive organisms are dead upon arrival; 3 = most of the invasive species that entered the pathway are still reproductively viable; 5 = invasive species are thriving in transit and have expanded populations, colonies or have enhanced their invasiveness capabilities).*)

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 8: What is the level or opportunities (0-5) for the pathway to facilitate spread to uncontaminated shipments during transport or during storage before/after transport (e.g., are shipments commingled and is cross-contamination a possibility)? (*Frame of Reference: A rating of 5 = 100% likelihood of co-mingled/cross contamination to uncontaminated hospitable shipments during transport or via pre/post transport/storage resulting in absolute dispersion of invasive species.*)

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 9: What is the level of prescreening effectiveness (e.g. detection) of invasive species prior to or during transport via this pathway? *(Frame of Reference: A rating of zero (0) equals indicates that virtually all invasives are detected and mitigated prior to or during transit. A rating of 5 indicates that there are no detection or mitigation methods for the invasives prior to or during transit)*

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 10: What is the level of difficulty (0-5) in detecting the invasive species once introduced? *(Frame of reference: A rating of zero (0) indicates that all invasives are detected immediately at the pathway endpoint. A rating of 5 indicates that the invasive species is/are so difficult to detect, there is a 100% likelihood they will be disseminated throughout the nation and become permanently established without detection)*

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 11: What is the assessment level (0-5) of the pathway's characteristics that would enable it to transport 'generalist' invasives that are capable of surviving in multiple habitats? *(Frame of Reference: An assessment of zero (0) indicates the pathway does not transmit any generalists. An assessment of 5 indicates the majority of invasives transmitted by this pathway are generalists with at least 3 or more populations capable of surviving in any of the pathway endpoints.)*

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 12: What is the level of risk of natural spread (rating of 0-5) posed by the invasive species transmitted via this pathway? *(Frame of Reference: A rating of zero (0) indicates the pathway transmits invasives with low reproductive rates or are fragile in any ecosystem other than that of its origination. A ranking of 5 indicates the pathway transmits invasives that are highly mobile, spread by wind, water and have fast/high reproductive rates in multiple ecosystems.)*

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 13: What is the level or risk of human/human activity (0-5) in spreading the invasives transmitted via this pathway? (Frame of Reference: A rating of zero (0) indicates that humans or human activities do not spread the invasive species. A rating of 5 indicates humans or human activities are the primary agent for the rapid spread of invasive species such as with Avian influenza).

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 14: What is the level of risk (0-5) of the pathway introducing an invasive that is known to be invasive but not yet in the U.S.? (Frame of Reference: A rating of 0 indicates that the pathway only transmits species that are already distributed throughout the endpoint ecoregion; a rating of 3 indicates the pathway transmits invasives that are in U.S ecoregions, but not in the endpoint of the pathway. A ranking of 5 indicates the pathway transmits viable invasives into pristine eco-systems).

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 15: What is the level (0-5) of available control options for the invasives transmitted via this pathway? (Frame of Reference: A rating of zero (0) indicates there are comprehensive control options that mitigate all invasives transmitted via the pathway. A rating of 5 indicates there are no control options for the invasives transmitted via the pathway.)

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

Question 16: What is the assessment of economic cost (0-5) of control options for invasive species transmitted via this pathway? (Frame of Reference: A rating of zero (0) indicates control options are a part of routine operations and therefore requires no additional funding. A rating of 5 indicates control options are so expensive, it requires the petitioning of external agency/multi-source emergency funding to control/eradicate.)

Level Nbr	Level Descriptor	Level Determination (i.e., 0,1,2,3,4, or 5) (Assign a whole number):	
Level 0	No Risk	Rationale	
Level 1	Extremely Low Level of Risk		
Level 2	Moderately Low Level of Risk		
Level 3	Medium Level of Risk		
Level 4	Moderately High Level of Risk		
Level 5	Extremely High Level of Risk		

Is there uncertainty regarding this rating? If so, please complete the chart below:

Basis of Uncertainty	Check All Relevant	Uncertainty level (Assign whole nbr from 0-5 where 1= slightly uncertain; 5= highly uncertain)	
Flaws in methodology		Rationale	
Lack of expertise			
Lack of coherence on issue			
Biological unknowns			
Insufficient information			
Political impediments			
Other-Define			

4) Step 4 Calculating Risk Individual/Consensus Score

After each single question is provided a score, this portion of pathway assessment requires the awarding of a final, overall assessment number (i.e., 0-5). No partial numbers are to be awarded. The process for awarding the single risk score follows:

A.	Tally overall pathway risk rating (Single/Consensus rating 0-5 expressed in whole number. Is the average of all per question ratings.)	
B.	Tally overall uncertainty ratings (Single/Consensus rating 0-5) expressed in whole number. Is the average of all per question uncertainty ratings)	
C.	Tally Revised/Final Pathway Risk Rating after considering uncertainty issues. (Is usually the same as rating in #A - -but not necessarily. Represents a compromise or adjusted rating reflective of the best determination after consideration of uncertainty. Is a whole number)	

Stage III- Invasiveness Scale (1-75)

Based on the above analyses, there are now 3 major factors upon which to assign a pathway ranking: impact category, pathway scale and pathway risk factors. Using the chart below, assign a risk prioritization (on scale of 1-75) for the pathway.

Example 1: Ballast Water

Impact Category	Pathway Scope	Pathway Risk Level
A Human	V	4

Example 2: Wood Packing Material

Impact Category	Pathway Scope	Pathway Risk Level
B Economy	V	3

1. Define Risk Impact Category	2. Select Pathway Scope Column (i.e., V, IV, II, II or I) 3. Select Pathway Risk Level (i.e., 5, 4, 3, 2 or 1) 4. Assign Corresponding Rank Order (i.e., single integer between the numbers 1-75)						NOTE: Any scope values of 0 indicate a local event and as such cannot be classified as a true pathway. However, these events provide areas for future observation or query.
A Level Human Health	75. V – 5	70. IV – 5	65. III – 5	60. II – 5	55. I – 5	0 – 5	
	74. V – 4	69. IV – 4	64. III – 4	59. II – 4	54. I – 4	0 – 4	
	73. V – 3	68. IV – 3	63. III – 3	58. II – 3	53. I – 3	0 – 3	
	72. V – 2	67. IV – 2	62. III – 2	57. II – 2	52. I – 2	0 – 2	
	71. V – 1	66. IV – 1	61. III – 1	56. II – 1	51. I – 1	0 – 1	
B Level Economic Impacts	50. V – 5	45. IV – 5	40. III – 5	35. II – 5	30. I – 5	0 – 5	
	49. V – 4	44. IV – 4	39. III – 4	34. II – 4	29. I – 4	0 – 4	
	48. V – 3	43. IV – 3	38. III – 3	33. II – 3	28. I – 3	0 – 3	
	47. V – 2	42. IV – 2	37. III – 2	32. II – 2	27. I – 2	0 – 2	
	46. V – 1	41. IV – 1	36. III – 1	31. II – 1	26. I – 1	0 – 1	
C Level Ecological Impact	25. V – 5	20. IV – 5	15. III – 5	10. II – 5	5. I – 5	0 – 5	
	24. V – 4	19. IV – 4	14. III – 4	9. II – 4	4. I – 4	0 – 4	
	23. V – 3	18. IV – 3	13. III – 3	8. II – 3	3. I – 3	0 – 3	
	22. V – 2	17. IV – 2	12. III – 2	7. II – 2	2. I – 2	0 – 2	
	21. V – 1	16. IV – 1	11. III – 1	6. II – 1	1. I – 1	0 – 1	

As such the initial ranking of the above exemplar pathways would be:

Ex 1: Ballast Water = Risk Ranking of 74

Impact Category	Pathway Scope	Pathway Risk Level
A – Human	V	4

Ex 2: Wood Packing = Risk Ranking of 48

Impact Category	Pathway Scope	Pathway Risk Level
B – Economy	V	3

Stage IV. Situational Modifiers of Pathway Risk Ranking

As previously indicated, there are certain factors which should be considered and then used to adjust the above rankings. The intent of the system is to provide a method of stratifying risk based upon national priorities (i.e., human, then economical and finally ecological impact), pathway scope and pathway risk factors. These are all qualitative measures for socio-political-economic systems. As such, the method must be sufficiently flexible to modify these rankings based upon other relevant factors. These relevant factors include the following:

1. Does the pathway transport invasives that are known to cause impact to human infrastructures (i.e., plant that lowers property values)?
2. Does the pathway transport invasives known to cause impacts to biologic/primary productivity/living industries (i.e., ecotourism, birding, aquatic recreation)?
3. Does the Pathway transport invasives that are known to have political or public sensitivity beyond that scientifically associated with the pathway (i.e., sensationalism of 'killer bees', endangered species)?

For instance, in the second example, the ranking was as below:

Example 2: Wood Packing Material = Risk Ranking of 48

Impact Category	Pathway Scope	Pathway Risk Level
B – Economy	V	3

However, if it is found that a new human health invasive is being transmitted through similar foreign pathways that intersect with this particular U.S. pathway, it might be advisable to reevaluate the impact category to the "A" level. The final risk ranking would then be reevaluated as 73 - -at the top of the list.

CHAPTER 4 - CONCLUSIONS FOR POLICY AND ACTION

From Science to Pathway Policy

In the process of developing the pathway diagrams, assessment tool, and assessment methodology, the Pathways Work Team struggled with several issues relevant to scientific data and public policy. While this report in no way attempts to resolve such intricate issues, it is essential that these considerations be brought to the forefront for future decision-making efforts and as such are enumerated below:

- There is a need to maximize the contributions of science for commercial/societal ends.
- International competitiveness is impacted by invasive species.
- Science-based decision-making should be open to public scrutiny.
- Pathway ranking combines community, government and corporate interests.
- Sound science, transparency and consistency are essential for formulating policy.
- Need neutrality in scientific advice to decision makers.
- Private sector has a role in setting the agenda.
- Invasive Species prevention is inherently an international activity.
- Methodology must include public and expert participation.
- Process for evaluating pathway risks is as important as assessment tools/criteria
- Outcome of process is the characterization of relative risk of pathway. It is up to policy makers to later devise plans for pathway management, resource leveraging, policy development, budget decisions and technology transfer/development.
- Invasiveness is predictable and can be controlled.
- Science can help understand the current condition under which decisions are being made and can define potential future consequences of those decisions.
- Uncertainty issues must be addressed and include such aspects as lack of coherence, lack of scientific data, areas of inaction, need for clarification, the state of confidence a scientist has regarding a particular phenomenon, diversity of values or interests, different definition of objectives; or different definition of measures.
- Most important decisions are made with a high degree of uncertainty but are justified by high level of commitment to set goals and values.
- Policy decisions are based on what the future should look like for particular groups; with consideration made of 'current situation' issues.

The bottom line agreed upon by all was that policy decides the direction to take, but science maintains the focus.⁶

Interpreting Invasiveness Scales

The next, logical question, therefore, is what does the above evaluation accomplish. The uses for the pathway prioritization scale include the following:

- (1) Common Value of Human Health First, Economy then Ecology.** Regardless of various agency/industry mission or priorities, this method of pathway prioritization

⁶ Source: Arizona State University Consortium for Science, Policy and Outcomes, College of Liberal Arts and Sciences

creates a common value: human health is the most salient concern followed by economy, then ecology.

- (2) **Mission Based Priorities.** Managing and prioritizing pathways has to be inextricably linked to organization mission and goals. This pathway prioritization method is a tool to assist agencies in defining and addressing invasive species issues - - and is not a 'stand alone' arbitrary exercise.
- (3) **Ecoregion Integration.** Using an ecoregion approach enables ecological issues to be imbued in the process, while giving latitude in definition of pathways based upon actual impact as opposed to regional governmental boundaries.

NISC and Cross-Agency Analysis

Once agencies have gone through the first 'triage' of pathway prioritization, it is anticipated these results will be shared with the National Invasive Species Council. NISC can then inform the various agencies as to which pathways they share with similar priorities. This 'matching' would then enable strategic grouping of organizations and experts for matrixed, systemic pathway prioritization and analysis, nationwide. And again, this tool could be the focus for that analysis. A long term goal would be for these mechanisms to eventually evolve into an online library of benchmarked pathway risk analyses and datasets. Appendix B contains recommended issues/question that should be addressed in cross-agency decisions.

Future Pathway Assessment Activities

The Pathways Work Team strongly feels that, though this is a great leap in sophistication of pathways prioritization efforts, we still have a long way to go - -particularly in the area of database integration and developing predictive statistical algorithms.

As such, this second edition of the ranking methods will also have to be field tested via focus groups to accomplish further refinements. We expect there to be at least two more edifications prior to "perfection". The Pathways Work Team found that each phase or format has to be 'tried and true' by users; though the consensus was - - we're on the right track.

Comments regarding this guide
may be forwarded to
National Invasive Species Council
Prevention Committee
Pathways Working Team
via e-mail to:

penny.e.kriesch@aphis.usda.gov

APPENDIX A: Sponsorship

This conference was co-sponsored by the U.S. Department of Interior, National Invasive Species Council, Prevention Committee, the Pathways Working Group and the U.S. Department of Agriculture, Animal and Plant Health and Inspection Service, Plant Protection and Quarantine. An immeasurable amount of gratitude is expressed to the following cooperators, advisors, and experts that so diligently dedicated their resources for invasive species pathways activities:

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International Union of Concerned Scientists
Louisiana State University
Maine Lakes Conservancy Institute
Minnesota Crop Improvement Association
National Aeronautics Space Administration
National Aquaculture Association
National Association State Departments of Agriculture
National Fish and Wildlife Foundation
Native American Fish and Wildlife Society
North American Brown Tree Snake Control Team, Texas A&M University
North American Weed Management Association
North Carolina Department of Agriculture and Consumer Services
Northeast Midwest Institute
Ocean Conservancy
Office of Secretary of Defense- Armed Forces Pest Management Board
Oregon Department of Agriculture
Oregon State University
Pacific Wildlife Research, Inc.
Pet Industry Joint Advisory Council
Smithsonian Environmental Research Center
Taylor Shellfish Farms
The Nature Conservancy
University of Florida
University of Georgia
U.S. Coast Guard
U.S. Geological Survey
U.S. Department of Agriculture
U.S. Department of Commerce
U.S. Department of Health and Human Services
U.S. Department of Homeland Security
U.S. Department of the Interior
U.S. Department of State
U.S. Department of Transportation
U.S. Trade Representative

APPENDIX B: Matrix-Agency Strategic Planning Considerations

The Pathways Work Team was charged with developing methodologies for assessing the relative risk of invasive species via distinct pathways. This process is not a policy decision-making effort but one wherein joint perspective of relative risk is developed by all persons with vested interest. However, the Team does recommend the following questions be responded to by appropriate parties to further the pathway analysis towards its eventual outcome: policy decisions, resource leveraging, budget actions, and scientific technology transfer and development in an integrated industry, public and government environment:

Policy and Program Conduct

What policy/program will or should be created to carry out the pathway findings/recommendations?

Who is responsible for data collection, analysis and reporting?

What entities monitor assessment/program activities?

What entities will periodically review and evaluate the program and its elements?

What is the cost benefit to proposed actions?

What are the indicators that actions are achieving the desired outcomes?

What are the criteria for evaluation success of pathway management?

Public Reporting

How are results/outcomes shared among various vested stakeholders?

What is the best method for sharing information with the stakeholders?

Databases

What databases exist that can be used for pathway analysis?

What is the best structure for integrating the information from the databases?

What elements need to be collected and used?

Budget

What are the fiscal issues that need to be incorporated into the policy to foster institutional excellence (i.e., Government Performance Results Act)?

Strategic Planning

Who is responsible for developing and carrying out cross-agency/stakeholder strategic plans for invasive species prevention?

What incentives can be developed to ensure compliance with strategic objectives, tasks and deliverables?

APPENDIX C: Contacts List

-----A-----

Allen Auclair
U.S. Army Garrison
Aberdeen Proving Ground
Directorate of Installation Operations
U.S. Army Environmental Center
Installation Restoration Division
5179 Hoadley Road
Aberdeen Proving Ground, MD 21010-5401
Phone: 410-306-1146
Fax: 410-436-2483
amssloglo@apg.army.mil

Kay Austin
International Joint Commission
1250 23rd Street, NW Suite 100
Washington, DC 20440
austink@ijc.org
phone: 202-736-9011
fax 202-467-0746

-----B-----

Dr. George K Beck
Colorado State University
Department of BioAgricultural Sciences
and Pest Management
Room 116 Weed Lab
Plant Science Building
Fort Collins, CO 80523-117
Phone 970-491-7568
Fax 970-491-3862
Email: GeorgeBeck@Colostate.edu

Gary M Beil
Minnesota Crop Improvement Association
1900 Hendon Avenue
St. Paul, MN 55108
Phone 1-800-510-6242
Fax 612-625-3748
Email: beilx001@umn.edu

John Berry
National Fish and Wildlife Foundation (NFWF)
1120 Connecticut Ave., NW
Suite 900
Washington, DC 20036
Phone: 202-857-0166
Fax: 202-857-0762

Herbert T. Bolton
U.S. Army Environmental Center
ATTN: SFIM-AEDC-CDC
Aberdeen Proving Ground, MD 27010
Or

USDA/CSREES
Mailstop 2220
1400 Independence Ave., S.W.
Washington, D.C. 20250-2220

Elizabeth C. Bourget
International Joint Commission
Secretary, U.S. Section
1250- 23rd Street, NW Suite 100
Washington, DC 20037
Phone 202-736-9008
Fax 202-467-0746
Email: bourgetl@washington.ijc.org

Terry L. Bourgoin
Director , Division of Plant Industry
Maine Dept. of Agriculture
Deering Bldg AMHI Complex
28 State House Station
Augusta, ME 04333-0028
Phone: 207-287-3891
Fax: 207-287-7548
E-mail: terry.bourgoin@state.me.us

E. Shippen Bright
Maine Lakes Conservancy Institute
P.O. Box 55
Nobleboro, ME 04555
Phone 207-563-5253
e-mail: Director@mlici.org

Kerry Britton
USDA Forest Service
Forest Health Protection
1601 N. Kent Street
Arlington, VA 22209
Phone: 703-605-5347
Fax: 703-605-5353
Email: kbritton01@fs.fed.us

David Brooks
U.S. Trade Representative
202-395-9579
dbrooks@ustr.gov

A Gordon Brown
Department of Interior
National Invasive Species Council
1201 Eye Street, NW; 5th Floor
Washington, DC 20005
Phone: 202-354-1878
Fax 202-371-1751
Email: A_Gordon_Brown@ios.doi.gov

-----C-----

Faith T. Campbell, Ph.D.
Senior Policy Representative
Introduced Forest Insects and Diseases
The Nature Conservancy
4245 North Fairfax Drive
Arlington, VA 22203
Phone: (703) 841-4881
FAX: (703) 841-2722
E-mail: phytodoer@aol.com
fcampbell@tnc.org

Earl Campbell
Fish Wildlife Services
Phone: 808-792-9414
Cell: 808-226-6076
Email: earl_campbell@fws.gov

Jonathan Champion
jchampion@nemw.org for
Allegra Cangelosi
Senior Policy Analyst, Northeast-Midwest Institute
218 D St.
Washington, DC 20003
Phone: 202-464-4007
FAX: 202-544-0043
E-mail: acangelo@nemw.org

Deborah J. Cavett (Facilitator)
Director, Interagency Initiatives
Science and Education Resources Development
Cooperative State Research, Education and
Extension Service
Phone: 202-720-6346
FAX: 202-720-3945
Mailing Address: 1400 Independence Ave SW Stop
2250; Washington, DC 20250
Express mail Delivery: 800 9th Street SW Rm 3312
Washington, DC 20024

Craig Clark
USDA APHIS; Wildlife Services
Phone 671-635-4400
Craig.s.clark@aphis.usda.gov

Andrew Cohen
7770 Pardee Lane; 2nd Floor
Oakland, CA 94621-1424
Phone: 510-746-7637
Fax: 510-746-7300
e-mail: acohen@sfei.org

Susan D. Cohen
USDA APHIS PPD, 3C42
4700 River Road, Unit #117
Riverdale, MD 20737
Phone: (301) 734-5929
FAX: (301) 734-5899
E-mail: susan.d.cohen@aphis.usda.gov

Wilhem Colemar
colemar@doacs.state.fl.us ;
phone 850-488-4033

Diane Cooper
Taylor Shellfish Farms
SE 130 Lynch Road
Shelton, WA 98584
Phone 360-426-6178
Fax 360-427-0327
dianec@taylorshellfish.com

Joseph Corn
University of Georgia
SE Cooperative Wildlife Disease Study
Wildlife Health Building
College of Veterinary Medicine
Athens, GA 30602-7393
706-542-1741
jcorn@vet.uga.edu

Gene Cross, Plant Pest Administrator
Plant Industry Division
NC Department of Agriculture and Consumer
Services
National Plant Board Liaison
1060 Mail Service Center
Raleigh, ND 27699-1060
(919) 733-6930, ext. 213
Gene.Cross@ncmail.net

-----D-----

Hilda Diaz-Soltero
USDA Senior Invasive Species Coordinator
1201 Eye Ste. N.W. 5th Floor
Washington, DC 20005
Phone 202-513-7249
Fax 202-371-1751
Email: hdiazsoltero@fs.fed.us

Bill Dickerson
NC Depart of Agriculture and Consumer Services
National Plant Board Liaison
1060 Mail Service Center
Raleigh, ND 27699-1060
Phone 919-733-3933
Fax 919-733-1041
Email: bill.dickerson@ncmail.net

Robert Doudrick
USDA Forest Service
North Central Research Station
1992 Folwell Avenue
St Paul, MN 55108
Phone: 651-649-5295

-----E-----

Pete Eagan
Armed Forces Pest Management Board
Forest Glen Section
WRAMC, Bldg 172
Washington, DC 2307-5001
Phone 301-295-7476
Email: Peter.egan@osd.mil

Roger Eberhardt
Office of the Great Lakes, Michigan DEQ
Hollister Building, 6th Floor
106 West Allegan Street
P.O. Box 30473
Lansing, MI 48909
Phone 517-335-4056/
Fax -517-335-4531
Direct line 517-335-4227
Email: eberharr@michigan.gov

Orlo (Bob) Ehart
Animal and Plant Health Safeguarding Coordinator
NASDA, Suite 1020
1156 15th Street., NW
Washington, DC 20005-1711
Phone; 202-296-9680 ext 214
Fax: 202-296-9686
Email: bob@nasda.org

Rachel Eichelberger
U.S. Department of Interior
National Invasive Species Council
U.S. Department of Interior (OS/SIO/NISC)
Mailing Address: 1849 C Street. NW
Washington, DC 20240
Physical Address: 1201 Eye Street NW
Fifth Floor Room 79
Washington DC. 20005
rachel_eichelberger@ios.doi.gov

Lucius G. Eldredge
Pacific Science Association
The Bishop Museum
1525 Bernice Street
Honolulu, HI 96817
Phone 808-848-4124
Fax 808-847-8252
Email: psa@bishopmuseum.org

Elizabeth Etchells
Deputy Director for Environmental Reviews
USTR – Environment and Natural Resources
Phone: 202-395-6130
e-mail: eetchells@ustr.gov

Dr. Everett
U.S. Coast Guard
Aquatic Nuisance Species Program

Environmental Standards Division (G-MSO-4) 2100
2nd Street, S.W.
Phone: 202-267-2243
Email: reverett@comdt.uscg.mil

-----F-----

Christopher Fisher
Colville Confederated Tribes
Fed Ex 23 Brook Tracts Road, Omak, WA 98841
P.O. Box 150, Nespelem, WA 99155
Phone 888-881-7684 ex 2110
509-634-2200
fax 509-634-4116
email: chris.fisher@colvilletribes.com

Dr. Jeffrey P. Fisher
Ecology and Conservation Officer
Bureau of Oceans and International
Environmental and Scientific Affairs
U.S. Department of State
Washington, D.C. 20520
Phone: (202) 647-6867
FAX: (202) 736-7351
E-mail: FisherJP@state.gov

Pam Fuller
U.S. Geological Survey – Bio. Res. Discipline
Nonindigenous Aquatic Species Program
Center for Aquatic Resources Studies
7920 NW 71st Street
Gainesville, FL 32653
Phone: (352) 264-3481
FAX: (352) 378-4956
E-mail: Pam_Fuller@usgs.gov

-----G-----

Richard Gaskalla
Director Division of Plant Industry
Florida Dept. of Agriculture & Consumer Services
P. O. Box 147100
Gainesville, FL 32614-7100
Phone: 352-372-3505
Fax: 352-955-2300
E-mail: gaskalr@doacs.state.fl.us

Jan Gilbreath
Trade Team; Ofc of International Affairs
U.S. Environmental Protection Agency
Washington, D.C.
Phone: (202) 564-6279
FAX: (202) 565-2409
Cell: (703) 587-9083
E-mail: gilbreath.jan@epa.gov

Sharon K. Gross
Asst. Prgm Coord -- Invasive Species
U.S.G.S.– Bio. Res. Discipline
12201 Sunrise Valley Drive, MS 301
Reston, VA 20192
Phone: (703) 648-4076
FAX: (703) 648-4238 (or 4039)
E-mail: sgross@usgs.gov

Vincent G. Guida, PhD
Research Fisheries Biologist
US Department of Commerce
NOAA Fisheries
Northeast Fisheries Science Center
J.J. Howard Laboratory
Highlands, NJ 07732
Phone: (732) 872-3042
FAX: (732) 872-3128
E-mail: vincent.guida@noaa.gov

-----H-----

Robert Haack
USDA Forest Service
North Central Research Station
1992 Folwell Avenue
St. Paul, Minnesota 55108-1034
Phone 517-355-7740 ex 108
rhaack@fs.fed.us

Scott Hardin
Florida Fish and Wildlife Conservation Commission
Exotic Species Coordination Section
620 South Meridian Street
Tallahassee, FL 32399-1600
Email: scott.hardin@myFWC.com
Phone: 850-488-4068
FAX: 850-413-0381

Catherine Hazlewood
The Ocean Conservancy
2029 K Ste NW
Wash., DC 20006
Phone: 202-429-5609
Fax 202-872-0619
Email: chazlewood@oceanconservancy.org

Dr. S.E. Henke
North American Brown Tree Snake Control Team
(NABTSCT)
Department of Animal and Wildlife Service
Texas A&M University – Kingsville
Caesar Wildlife Research Institute
700 University Blvd, MSC 218
Kingsville, Texas 783-8202
Phone 361-593-3689
Fax 361-593-3788
Email: scott.henke@tamuk.edu

Michael Hennessey, Ph.D., (Facilitator)
Entomologist Pathways & Standards Team Ldr
USDA APHIS PPQ CPHST
Plant Epidemiology & Risk Analysis Laboratory
1730 Varsity Drive, Suite 300
Raleigh, North Carolina 27606-5202
Phone: (919) 855-7514
FAX: (919) 855-7595
E-mail: Michael.k.Hennessey@aphis.usda.gov

Jim Hester
Agency Environment Coordinator
USAID
Bureau Economic Growth, Agriculture and Trade
1350 Pennsylvania, Avenue, NW
Washington, DC 20523
Phone 202-712-5176
Email: jhester@usaid.gov

Dan Hilburn
Administrator, Plant Division
Oregon Department of Agriculture
635 Capitol St., NE
Salem, OR 97301-2532
Phone: 503-986-4663
Fax: 503-986-4786
E-mail: dhilburn@oda.state.or.us

Jeffrey E. Hill
Associate Research Faculty
Tropical Aquaculture Laboratory
University of Florida
1408 24th Street SE
Ruskin, FL 33570
Phone: 813 671-5230 x 118
Fax 813-671-5234
Email jehill@ifas.ufl.edu

Sandra Howard
Ofc of the Assistant Secretary for
Planning and Evaluation
U.S. DHHS
200 Independence Ave., SW, MS 445F
Washington, DC 20201
Phone 202-690-5874
Fax 202-205-8835
Email: Sandra.howard@hhs.gov

Dr. Martin Hugh-Jones
Louisiana State University
Department of Pathobiological Sciences
School of Veterinary Medicine
Baton Rouge, LA 70803
Phone: 225-578-5599
Fax: 2258-578-9701
Email: mehj@vetmed.lsu.edu

-----J-----

Jerome A Jackson
Florida Gulf Coast University
Whitaker Center for Science/Math and Technical
Education; College of Arts and Sciences; Whitaker
Hall Room 222
10501 FGCU Boulevard South
Fort Myers, FL 33965-6565
Phone: 239-590-7193
Email: jjackson@fgcu.edu

Dr. Whitman Miller *For* Susan Jiacinto
Smithsonian Environmental Res Center
P.O. Box 28; 647 Contees Wharf Rd
Edgewater, MD 21037-0028
Phone: 443-482-2400
Fax: 443-482-2380
jiacintos@si.edu

Kathleen J.R. Johnson
Oregon Department of Agriculture
Insect Pest Prevention & Mgmt Section
Plant Division
635 Capitol St. NE
Salem, OR 97301
phone: 503-986-4636
800-525-0137
fax 503-986-4786
email kjohnson@oda.state.or.us

-----K-----

Timothy R.E. Keeney
ANSTF
Department Ass't Sec of Oceans and Atmosphere
Dept of Commerce, NOAA
Herbert Hoover Bldg., Room 5804
14th St and Constitution Ave., NW
Washington, DC 20230
Phone 305-292-0311
e-mail Timothy.Keeney.Jr@noaa.gov

Henry Kelly
Federation of American Scientists
1717 K Street NW Suite 209
Washington, DC 20036
Phone: 202-546-3300
Fax: 202-675-1010

Sheilah Kennedy
North American Weed Management Association
P.O. Box 1910, 461 E Agate
Granby, CO 80446-1910
Of P.O. Box 4
Kanogan, WA 98840-0004
Phone: 970-887-1228
Fax 970-887-1229
Cell 509-322-6909
Contact: Charles Henry at agwest@rkymtnhi.com

Arnold Konheim
Office of the Secretary
U.S. Department of Transportation
400 7th Street SW Room 10309G
Washington, DC 20590
Phone 202-366-4849
Fax 202-366-7618
Arnold.konheim@dot.gov

Richard W. Krichhoff
National Association of State Departments of
Agriculture
Washington Office
1156 15th Street, NW Suite1020
Washington, DC 20005
Phone: 202-296-6980
Fax: 202-296-9686

Penny E. Kriesch (Chair)
Agricultural Analyst
USDA APHIS PPQ PPCI
4700 River Road; Unit 156; Suite 4C73
Riverdale, Maryland 20737
Phone: (301) 734-8412
FAX: (301) 734-3396
E-mail: penny.e.kriesch@aphis.usda.gov

-----L-----

Lindsey Elizabeth Etchells
for Mark Linscott
USTR
Environment and Natural Resources
600 17th Street NW
Washington, DC 20508
Phone 202-395-7320
Email: mlinscott@ustr.gov; aklyler@ustr.gov

-----M-----

Donald R. MacLean
U.S. Fish and Wildlife Service
Division of Environmental Quality
Branch of Invasive Species
4401 N. Fairfax Drive, Room 300
Arlington, VA 22203
Phone: (703) 358-2108
FAX: (703) 358-1800
E-mail: don_maclean@fws.gov

Randy MacMillan
National Aquaculture Association
111 W. Washington Street, Suite
Charles Town, WV 25414
Phone: 304-728-2167
Fax: 304-728-2196
Email: naa@frontiernet.net

Steven McCormick
The Nature Conservancy
4245 North Fairfax Drive
Suite 100
Arlington, VA 22203-1606

Jerry Melillo
Ecological Society of America
1707 H Street NW; Suite 400
Washington, DC 20006
Phone 202-833-8773
Direct phone: 508-289-7494
Fax 202-833-8775
Email: jmelillo@mbl.edu

Kathy Metcalf
Director, Maritime Affairs
Chamber of Shipping of America
1730 M Street, NW; Suite 407
Washington, DC 20036
Phone: 202.775.4399
Fax: 202.659.3795
E-Mail: KMetcalf@knowships.org

N. Marshall Meyers
Pet Industry Joint Advisory Council; Suite 400; 1220
19th Street, NW
Washington, DC 20036
Phone 202-452-1525
Fax 202-293-4377
Email: mmeyers@pijac.org

Dr. A. Whitman Miller
Assistant Director
SERC Invasions Research Program
National Ballast Information Clearinghouse.
P.O. Box 28; 647 Contees Wharf Road
Edgewater, MD 21037-0028
Phone: 443-482-2208
Fax: 443-482-2295
e-mail: miller@si.edu

LCDR Kathy Moore
Office of Operating and Environmental Standards
Division Chief, Aquatic Nuisance Species Program
U.S. Coast Guard (G-MSO-4)
2100 Second Street SW; Room 1601
Washington, DC 20593-0001
Phone: 202-267-0214

Bob Myers
USDA APHIS, Wildlife Services
4700 River Road, Cubicle 6A69
Riverdale, MD 20737
Phone: 301-734-5920
Email: Robert.p.myers@aphis.usda.gov

-----N-----

Douglas Neumann
Office of Ecology and Terrestrial Conservation
U.S. Department of State
2201 C. St. NW Room 4333
Washington DC 20520-6310
Phone: 202-647-1804
Email: neumanndb@state.gov

Ira New Breast
Native American Fish and Wildlife Society
8333 Greenwood Blvd
Denver, CO 80221
Phone 303-466-1725
Laurie Montour, project coordinator
Email: iranb@nafws.org

-----O-----

Carol L. Okada
Hawaii Department of Agriculture
1849 Auiki Street
Honolulu, HI 96819
Phone: 808-832-0566
Fax: 808-832-0584
Carol.l.okada@hawaii.gov

Charles R. O'Neill
New York Sea Grant Program
Great Lakes Program Coordinator
Phone 585-395-2516
Or 800-285-2285
Fax: 585-395-2466
Email : cro4@cornell.edu

Richard Orr (Guest Speaker)
Asst. Director for Int. Policy and Prevention
National Invasive Species Council
U.S. Department of Interior (OS/SIO/NISC)
Mailing Address: 1849 C Street. NW
Washington, DC 20240
Physical Address: 1201 Eye Street NW
Fifth Floor Room 79
Washington DC. 20005
Phone: (202) 354-1882
FAX: (202) 371-1751
E-mail: richard_orr@ios.doi.gov

-----P-----

Mamie Parker
ANSTF; Fishers and Habitat Conservation
U.S. Fish and Wildlife Service
Interior Building, Room 3245
1849 C Street. NW
Washington DC 20240
Phone 202-208-6394
Fax: 202-2087-4674
Email: mamie_parker@fws.gov. Is sending Everett
Wilson, email: Everett_wilson@fws.gov

Neelam Patel
Environmental Protection Agency
patel.neelam-r@epa.gov

Parul Patel
Offshore Pest Information System
OPIS Program Manager
Pest Detection & Mgmt Programs
USDA APHIS PPQ
4700 River Road; Unit 140
Riverdale, MD 20737
Phone: 301-734-8965
Fax: 301-734-8584
e-mail: parul.r.patel@aphis.usda.gov

Bivan Patnaik
Office of Operating and Environmental Standards
Ballast Water Management Commandant
U.S. Coast Guard (G-MSO-4)
2100 Second Street SW; Room 1601
Washington, DC 20593-0001
Phone: 202-267-0214

Gad Perry
Texas Tech
Phone: 806-742-2841 ex 228
Email: gad.perry@ttu.edu

Mike Pitzler
USDA APHIS
Wildlife Services
3375 Koapaka Street Suite H-420
Honolulu, HI 96819
Phone: 808-861-8576

-----R-----

Craig Regelbrugge
American Nursery and Landscape Association
1000 Vermont Avenue, 3rd Floor
Washington, DC 20005
Phone: 202-789-2900
Fax: 202-789-1893
e-mail: cregelbrugge@anla.org

Sarah Reichard

Center For Urban Horticulture
University of Washington
P.O Box 354115
Seattle, WA 98195-4115
Phone 206-616-5020
reichard@u.washington.edu

David F. Reid, Ph.D.
Dir, NOAA, National Center for Research on
Aquatic Invasive Species, U.S. Department of
Commerce; Great Lakes Environmental Res Lab
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-2945
Voice: (734) 741-2019
FAX: (734) 741-2055
E-mail: david.reid@noaa.gov

Connie Riherd
Assistant Director
Florida Dept. of Agriculture & Consumer Services
P. O. Box 147100
Gainesville, FL 32614-7100
352-372-3505 ext. 108
riherdc@doacs.state.fl.us

Lucinda Riley, J.D.
DHS/CBP, Director of Policy and Programs ;
Agriculture Inspection Policy and Programs
Tel. (202)-344-2433
Fax: (202)344-1442
LUCINDA.Riley@dhs.gov

Michael Ripley
Environmental Coordinator
Inter-Tribal Fisheries & Assessment Program
Chippewa Ottawa Resource Authority
179 West Three Mile Road
Sault Sainte Marie, MI 49783
Tel. (906) 632-0072
Fax. (906) 632-1141
mripley@sault.com

Anwar Rizvi
Senior Plant Pathologist
USDA APHIS PPQ ISPM
4700 River Road; Unit 134
Riverdale, MD 20737-1236
phone: 301-734-4313;
fax: 301-734-8584
e-mail: anwar.s.rizvi@aphis.usda.gov

Erich Rudyj (Facilitator)
USDA APHIS PPQ PPCI
4700 River Road
Riverdale, MD 20737
301-734-6748

Roger Rufe
Ocean Conservancy
2029 K Street
Washington, DC 20006
Phone: 202-429-5609

-----S-----

Jeffrey Schardt
Florida Department of Environmental Protection;
3900 Commonwealth Boulevard, MS 100
Tallahassee, FL 32397
Phone 850-245-2809
Fax 850-245-2128
Jeff.schardt@dep.state.fl.us

Anne Sergeant
National Center for Environmental Assessment
U.S. Environmental Protection Agency HQ Ariel Rio
Bldg; 8601 N;
1200 PA Avenue, NW
Washington, DC 20460
Phone 202-564-3249
Fax: 202-564-2018
Email: sergeant.anne@epa.gov

Edwin Sheffner
Applied Sciences Program, ICFS
Science Mission Directorate
Sun Earth System Division
NASA Headquarters; Mail 5L79
300 E Street, SW
Washington, DC 20546-0001
Email: Edwin.j.sheffner@nasa.gov

Thomas Sim
Administrator
Plant Protection and Weed Control Program
Kansas Department of Agriculture
PO Box 19282
Topeka, KS 66619-1282
Phone: 785-862-2180
Fax: 785-862-2182
E-mail: tsim@kda.state.ks.us

Michael Simon
USDA APHIS PPQ; Unit 11
Kahului Airport; Kahului, HI 96732
Phone 808-877-8757
Fax 808-877-9086

Michael Slimak
National Center for Environmental Assessment; U.S.
Environmental Protection Agency HQ; Ariel Rio
Bldg; 8601 N; 1200 PA Avenue, NW
Washington, DC 20460
Phone 202-564-3349
Fax: 202-564-2018
Email: slimak.michael@epa.gov

Colin D. Stewart, PhD
USDA APHIS Veterinary Service
National Center for Import/Export
4700 River Road, Unit 39
Riverdale, MD 20737-1231
Phone: 301-734-0650
Fax: 301-734-8226
e-mail: colin.stewart@aphis.usda.gov

Jeffrey Stone
Oregon State University
Department of Botany and Plant Pathology; Cordley
2082
Corvallis, OR 97331.2902
Phone: 541-737-3451
Fax: 541-737-3573
stonej@science.oregonstate.edu

-----T-----

Al Tasker
USDA APHIS PPQ
ISPM; Suite 5A45
4700 River Road
Riverdale, MD 20737
301-734-5708

John L. Teem, Ph.D.
National Aquaculture Association
Aquatic Nuisance Species Representative
111 W. Washington St. Ste 1
Charles Town, W.V. 25414
Direct Mail: FDACS/Aquaculture, 1203
Governor's Square Blvd.,
Tallahassee FL 32301
Phone: (850) 410-0867
FAX: (850) 410-0893
E-mail: teemj@doacs.state.fl.us

Ralph Their
USDA Forest Service
Forest Health Protection
1601 N. Kent Street
Arlington, VA 2209
Phone: 703-605-5336
Fax: 703-605-5353

Mark Tuchman
U.S. Environmental Protection Agency
Great Lakes National Program Office
77 West Jackson Blvd. G0J
Chicago, IL 60604-3590
Phone 312-353-1369
Email: tuchman.marc@epa.gov

John Turner
Bureau of Oceans and International Environmental
and Scientific Affairs
U.S. Department of State (OES/OA/MLP)
2201 C. Ste. NW; Room 7831
Washington, DC 20520
Phone 202-647-1554
Email: ferdinandcc@state.gov or
pannellmx@state.gov

-----V-----

Bob Venette
USDA Forest Service
North Central Research Station
1992 Folwell Avenue
St. Paul; Minnesota 55108-1034
Phone 651-649-5028
Fax 651-649-5256
Venet001@umn.edu

Dave Vesely
Pacific Wildlife Research, Inc
P. O. Box 1061
Corvallis, OR 97339
Phone 541-745-5025
Fax: 541-745-5841
Email: dvesely@pwri.com

David Brooks *for* Darci Vetter
Director for Sustainable Development
Office of the U.S. Trade Representative
600 17th St, NW
Washington, DC 20508
Phone: 202-395-9629
FAX: 202-395-9517
E-mail: dvetter@ustr.gov

Dan Vice
Ass't State Director
USDA Wildlife Services
HI/GU/Pacific Islands
e-mail: Daniel.s.vice@aphis.usda.gov

-----W-----

John Waugh
International Union for Conservation of
Nature and Natural Resources (IUCN)
1630 Connecticut Ave NW; 3rd Flr
Washington, DC 20009

Donna West
USDA/APHIS/PPQ
Senior Import Specialist
4700 River Road; 4C68
Riverdale, MD 20737
Phone: 301-734-5298
FAX: 301-734-3249
E-mail: Donna.L.West@aphis.usda.gov

Randy Westbrooks
U.S. Geologic Survey
233 Border Belt Drive; P.O. Box 279
Whiteville, NC 28472
Phone: (910) 640-6435
FAX: (910) 648-6763
E-mail: rwestbrooks@usgs.gov

Dean Wilkinson
Department of Commerce Liaison
National Invasive Species Council
1201 Eye Street, NW 5th Floor
Washington, DC 20005
Phone 202-513-7243
Fax 202-371-1751
Email dean_wilkinson@ios.doi.gov

Sherman Wilhelm (Replaced by Zajicek)
Florida Department of Agriculture and Consumer
Services; Div of Aquaculture; 1203 Governors Sq
Blvd, 5th Floor;
Tallahassee, Florida 32301
Phone 850-488-5471
Fax 850-410-0893
Email: wilhels@doacs.state.fl.us

Lyle Wong
Phone: 808-973-9535
Email lwongpi@yahoo.com

-----Z-----

Paul W. Zajicek
Florida Department of Agriculture and Consumer
Services
Division of Aquaculture
1203 Governors Sq Blvd, 5th Floor
Tallahassee, Florida 32301
Phone: 850-488-0893
Fax 850-410-0893
Email: zajicep@doacs.state.fl.us

Hamdallah Zedan
Global Invasive Species Program Secretariat
413 St-Jacques Street, 8th Flr, Ofc 800
Montreal, Quebec, Canada, H2Y 1N9
Phone 514-288-2220
Fax 514-288-6588
Email: secretarial@biodiv.org

APPENDIX D: Conference Background Research Materials List:

1. HAACK 2001 Intercepted Scolytidae (Coleoptera) at U.S. ports of entry: 1985–2000
2. APHIS Intercept 1 yr dunnage SWPM counts
3. APHIS intercept tiles SWPM counts
4. F.J. GAY 1969 Article - - Species Introduced by Man
5. APHIS PIN 309 Ad Hoc Report Results on Air Transport
6. Quarantine Risk Associated with Air Cargo Containers by P.D. Gadgil, L.S. Bulman and K.L. Glassey, July 2002
7. Insect Survival in Jet Aircraft by W. N. Sullivan, 1958
8. MIA cargo aircraft risk analysis
9. MIA cargo aircraft establishment
10. MIA cargo aircraft inspections analysis
11. MIA optimizing cargo inspections
12. Canadian Technical Report of Fisheries and Aquatic Sciences 2268 dated 1999 by Michel Harvey, Michel Gilbert, Danile Gauthier and Donald M. Reid
13. Genetic Identification and Implications of Another Invasive Species of Dreissenid Mussel in the Great Lakes by Bernie May and J. Ellen Marsden 1992
14. Mid-ocean exchange of container vessel ballast water. 2: Effects of vessel type in the transport of diatoms and dinoflagelaltes from Manzanillo, Mexico, to Hong Kong, China by Dickman dated 1999
15. Ballast-mediated animal introductions in the Laurentian Great Lakes: retrospective and prospective analyses by Igor A. Grigorovich, Robert I. Colautti, Edward L. Mills, Kristen Holeck, Albert G. Ballert, and Hugh J. MacIsaac 2003
16. Identifying hazards in complex ecological systems. Part 1: fault-tree analysis for biological invasions Keith R. Hayes 2002
17. Global hot spots of biological invasions: evaluating options for ballast-water management, John M. Drake and David M. Lodge 2004

[Note: Information provided in this report was collected from multiple sources during conference and via interviews. Should any of the provided information require further footnote, please contact Penny Kriesch at penny.e.kriesch@aphis.usda.gov for report notation.]

APPENDIX E: Conference Agenda

Agenda
National Invasive Species Council
Pathway Assessment Conference [GU1]
(Air Transport, Ballast Water, Wood Packing Material)
USDA APHIS Oklahoma Memorial Conference Center
Riverdale, Maryland, June 21-22, 2005

Day One – June 21, 2005

8:30	Coffee	
9:00[GU2]	Welcome Cmte	Penny Kriesch, USDA APHIS-NISC Prevention
[GU3]9:10	National Invasive Species Program	Richard Orr, Assistant Director for International Policy/Prevention, National Invasive Species Council, (NISC) U.S. Department of Interior
9:30	Pathways Analysis Project	Hilda Diaz-Soltero, Senior USDA Invasive Species Coordinator USDA Liaison, NISC
10:00	Instructions to Work Groups	Facilitation Team (Penny Kriesch)
10:15	Break	Adjourn to Work Groups
10:30	Individual Focus Groups	Conference-Rooms A/B/C
12:00	Training- Invasive Species Trends	Jeffrey P. Fisher, PhD[GU4], International Trade and U.S. Department of State, Bureau of Oceans and International Environmental & Scientific Affairs
	Lunch	
1:30	Focus Groups (In-Room break)[GU5]	Conference-Rooms A/B/C
3:30	Reconvene in Large Group Issues, Challenges, Next Steps	Pathway Focus Group Leads Conference Center Main Room
4:00	Adjourn	

Day Two – June 22, 2005[GU6]

8:30	Coffee	
9:00	Invasive Species: Data Mining	Susan Cohen, PhD, USDA APHIS Policy/Program Dev
9:15	Work Group Break-Outs	Conference-Rooms A/B/C
12:00	Training Video	AI Tasker, USDA APHIS, Noxious Weed Coordinator
1:30	Focus Groups (In-Room Break)	Conference-Rooms A/B/C
2:30	Focus Group Report Outs	Pathway Focus Group Leads- Conference Center Main Room
3:30	The Next Challenges for Pathway Prioritization	Faith Campbell The Nature Conservancy
3:45	Thanks and Adjourn	Penny Kriesch

APPENDIX F – Reserved For Future Development of Predictive Algorithms and Integrated Database Design

APPENDIX G: Revised Pathway Diagrams

Diagrammed Pathway Categorizations

(T) Transportation

T 1 Modes of Transportation

T1.1 Air

T1.2 Water/Aquatic

T1.2.1 Ship Ballast Water

T1.2.2 Hull/Surface Fouling (i.e., Recreational Boats and Vessels)

T1.2.3 Stowaways in Holds

T1.2.4 Superstructures/Structures Above Water Line

T1.2.5 Transportation/Relocation of Dredge Spoil Material

T1.3 Land Terrestrial

T1.3.1 Cars, Buses, Trucks, ATVs. Trailers for recreational boats

T1.3.2 Trains, Subways, Metros, Monorails

T1.3.3 Construction/Firefighting Vehicles

T1.3.4 Hikers, Horses Pets

T2 Military Travel and Transportation of Military Vehicles

T2.1 Baggage/Gear

T2.2 Equipment

T3 Items used in the Shipping Process

T3.1 Containers

T3.2 Packing Materials

T3.2.1 Wood Packing Materials

T3.2.2 Seaweed

T3.2.3 Other Plant Materials

T3.2.4 Sand/Earth

T4 Mail/Internet Overnight shipping

T5 Travel Tourism/Relocation

T5.1 Travelers Themselves

T5.2 Baggage/Gear

T5.3 Pets/Plants and Animals Transported for Entertainment

T5.4 Travel Consumables

T5.5 Service Industries

(L) Living Industry

L1 Plant Pathways

- L1.1 Importation of Plants for Research
- L1.2 Potting Soils, Growing Mediums, Sodds and Other Materials
- L1.3 Plant Trade (agricultural nursery, landscape, floral, raw logs)
 - L1.3.1 Plant Parts
 - L1.3.1.1 Above-Ground Plant Parts
 - L1.3.1.2 Below Ground Plant Parts
 - L1.3.1.3 Seeds and the Seed Trade
 - L1.3.1.4 Aquatic Propagules
 - L1.3.2 Whole Plants

L2 Food Pathways

- L2.1 Live Seafood
- L2.2 Other Live Food Animals
- L2.3 Plants and Plant Parts as Food

L3 Non-Food Animal Pathways

- L3.1 Bait
- L3.2 Pet/Aquarium Trade
- L3.3 Aquaculture
- L3.4 Non-Pet Animals
- L3.5 Release of Organisms for Religious, Cultural or Other Reasons

L4 Nonliving Animal and Plant Related Pathways

- L4.1 Processed and Partially Processed Meat and Meat Processing Waste
- L4.2 Frozen Seafood
- L4.3 Minimally Processed Animal Products
- L4.4 Minimally Processed Plant Products

(M) Miscellaneous

M1 Biocontrol

M2 Other Aquatic Pathways

 M2.1 Interconnected Waterways

 M2.1.1 Freshwater Canals

 M2.1.2 Marine/Estuarine Canals

 M2.1.3 Domestic Waste Streams

 M2.2 Interbasin Transfers

M3 Natural Spread of Established Populations

M4 Ecosystem Disturbance

M4.1 Long-Term (highway and utility rights-of-way, clearing, logging)

M4.2 Short Term (habitat restoration, enhancement, prescribed burning)

M5 Garbage

 M5.1 Garbage Transport

 M5.2 Garbage Landfill

APPENDIX H-Pathways Diagrams
Diagram 1

Categorization Of Pathways

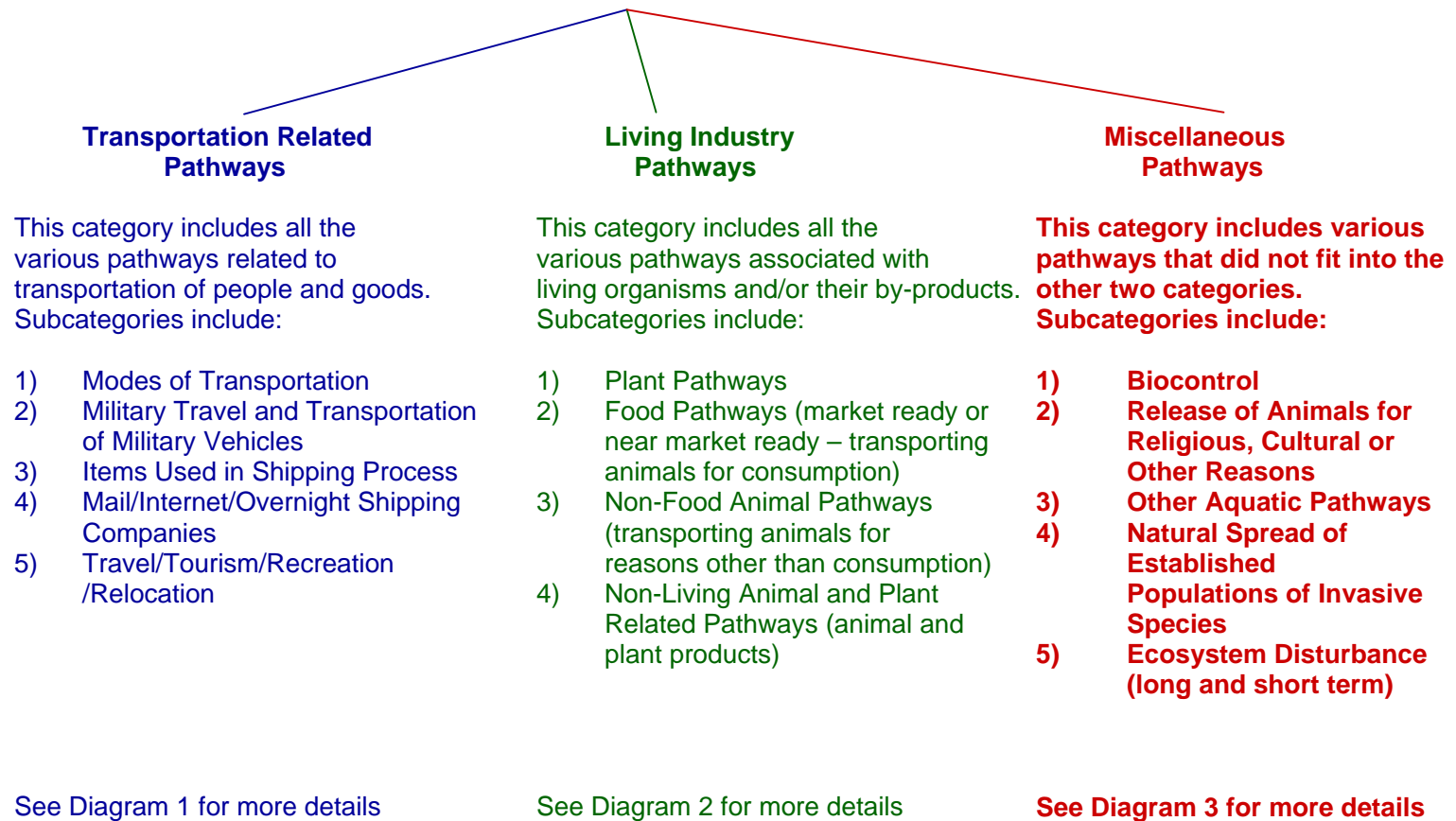


Diagram 2

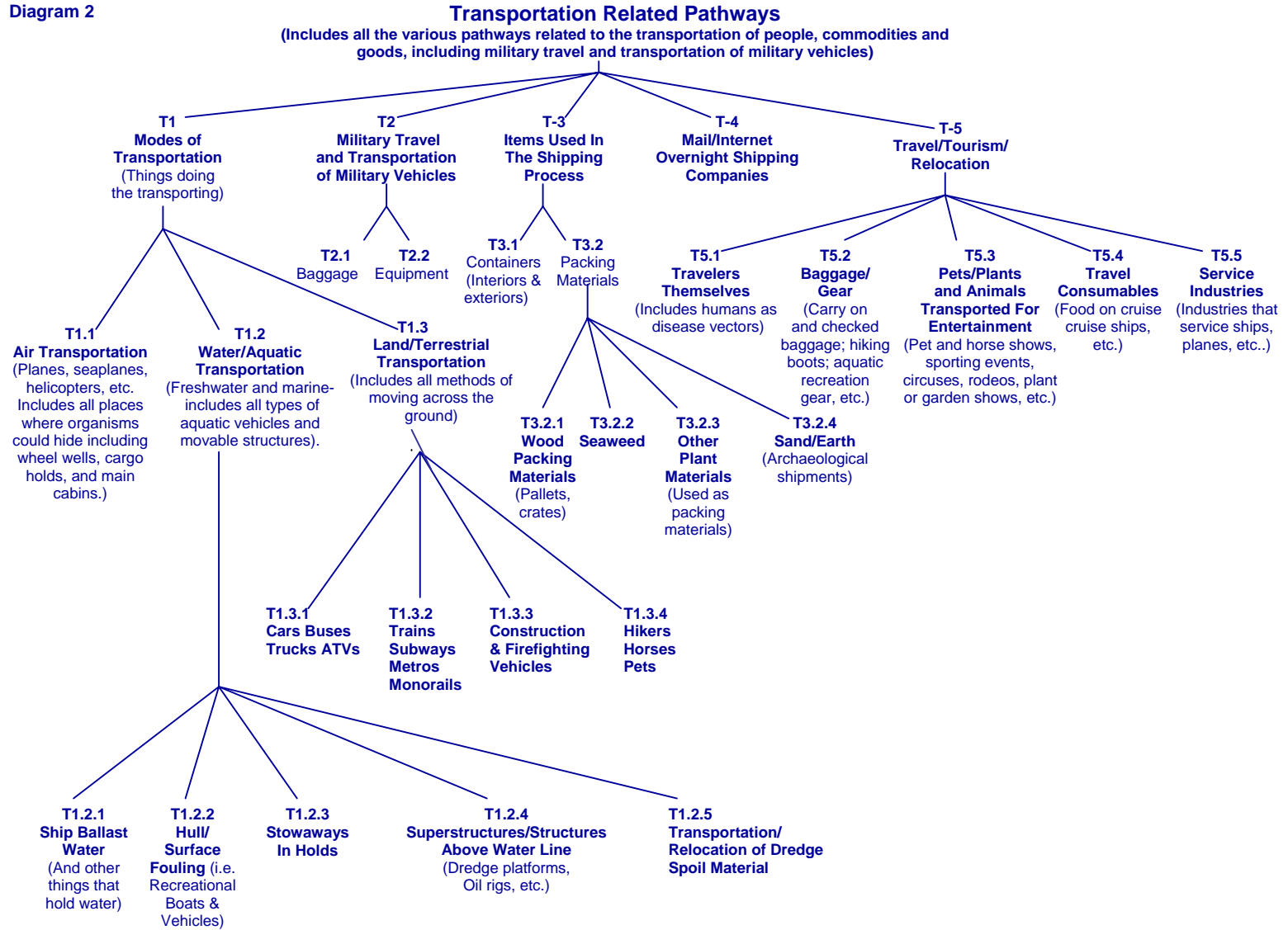


Diagram 3

Living Industry Pathways

(includes all pathways associated with living organisms and/or their by-products)

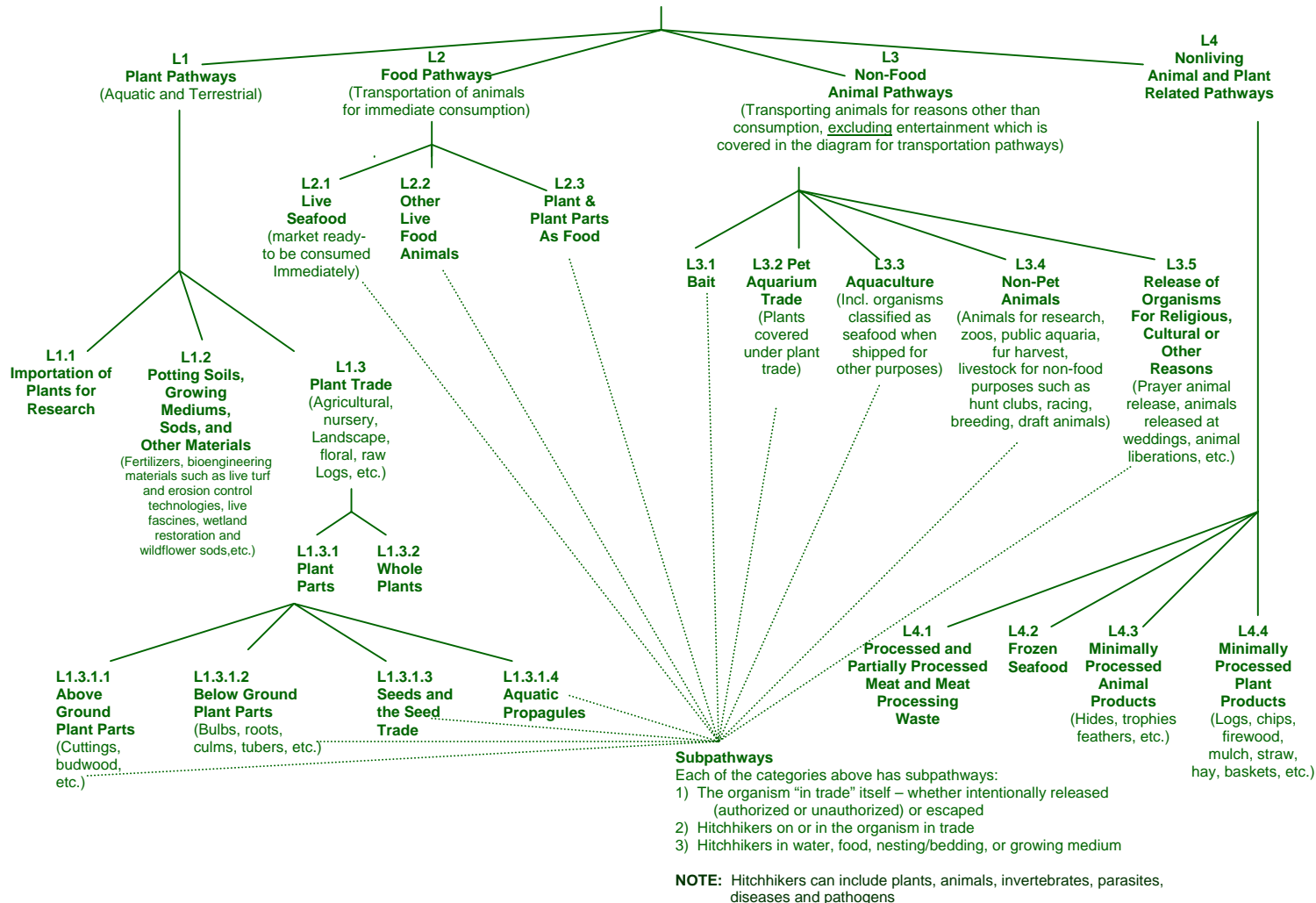
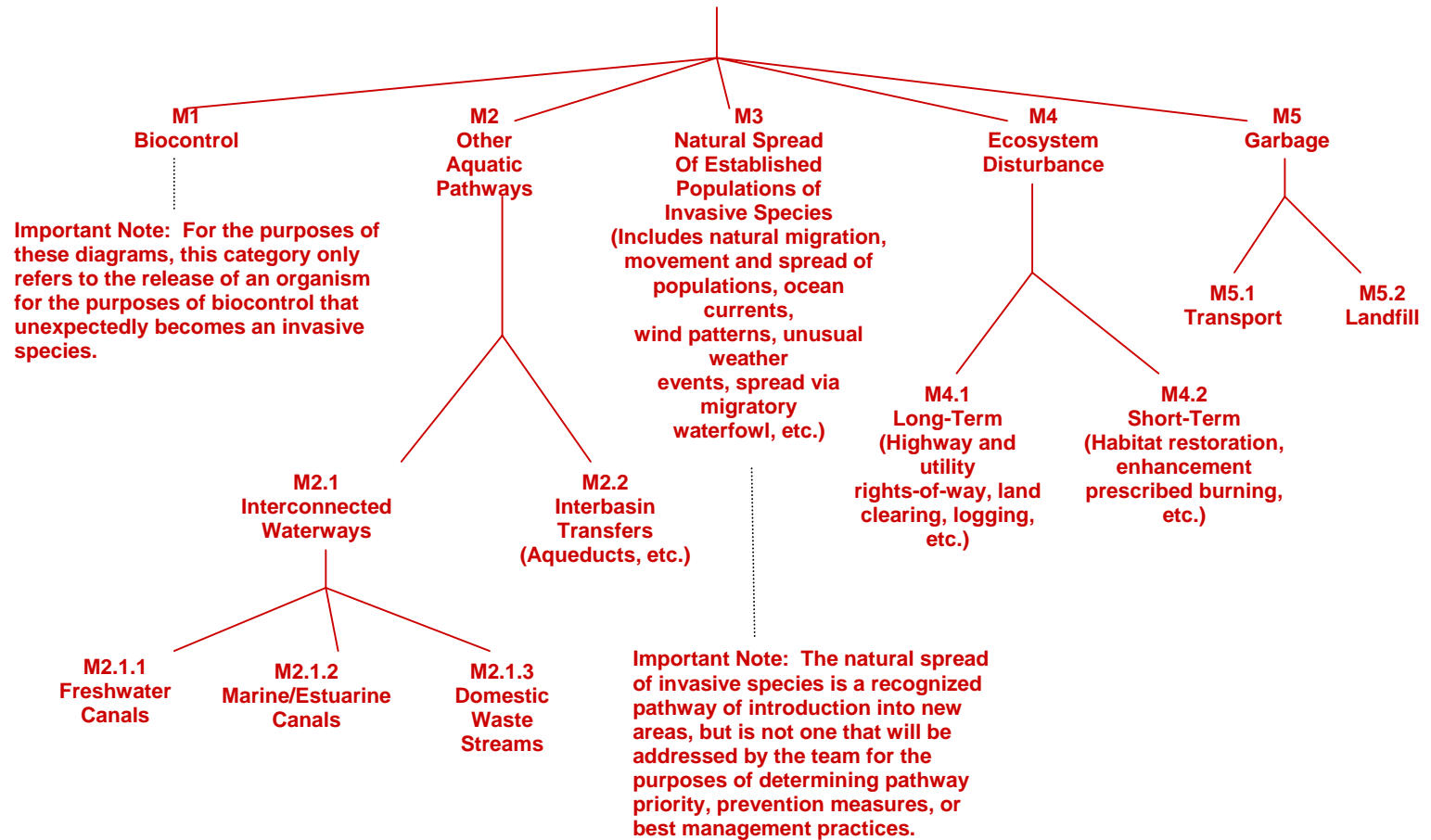


Diagram 4

Miscellaneous Pathways
(Includes various pathways that did not fit into the
Transportation or Living Industry Pathway Categories)



RESERVED