

## **Risk Assessment and Mapping Program (RAMP) Peer Review Summary**

This document provides a summary of the peer review of the Risk Assessment and Mapping Program (RAMP) and related documentation conducted at the request of the U.S. Fish and Wildlife Service (USFWS) during August-September 2014. This review was conducted to fulfill requirements established by the Office of Management and Budget (OMB) for influential science produced by Federal government agencies, as provided in their bulletin “Final Information Quality Bulletin for Peer Review,” issued on December 16, 2004.

Following the Federal agency guidance provided by OMB, USFWS developed a plan for the RAMP review utilizing an “Independent Peer Review” process for evaluation of a government science product categorized as “Influential Science.” The RAMP peer review plan was made available to the public on June 12, 2014 for a 30 day comment period on the website of the USFWS Office of the Science Advisor (<http://www.fws.gov/science/pdf/RAMP-Peer-Review.pdf>). No substantive comments were received during the public comment period. USFWS subsequently proceeded with identifying and inviting three subject matter experts to serve as the RAMP peer review panel. Reviewer expertise included any one or combination of the following disciplines: invasive species biology, invasive species risk assessment, decision-support modeling, aquatic species biology, aquaculture, fisheries, climate change, and climate modeling. Additionally, the peer reviewers had no involvement in the development of the RAMP.

The peer review panel was comprised of the following:

Dr. Patricia Koleff Osorio  
National Commission for the Knowledge and Use of Biodiversity in Mexico (CONABIO)  
Liga Periférico-Insurgentes 4903 Col. Parques del Pedregal,  
Delegacion Tlalpan  
Mexico City, Mexico; D.F. Mexico  
Tel: +52 55 5004 5005  
Email: [pkoleff@conabio.gob.mx](mailto:pkoleff@conabio.gob.mx)

Ms. Lacey Mason  
Institute for Fisheries Research  
University of Michigan  
400 North Ingalls Building  
NIB G250  
Ann Arbor, MI 48109-5480  
Tel: (734) 663-3554 (x12155)  
Email: [lmason@umich.edu](mailto:lmason@umich.edu)

Ms. Sara Gris -Stahlman  
Senior Coastal Outreach Specialist  
Pennsylvania Sea Grant  
301 Peninsula Drive, Suite 3  
Erie, PA 16505  
Tel: (814) 217-9011 (x109)  
E-mail: [sng121@psu.edu](mailto:sng121@psu.edu)

The RAMP peer review summary includes: 1) all standardized questions (total of 10) that were provided to the peer review panel for their use in conducting the review, 2) questions and comments subsequently submitted by the peer review panel members to the principal investigators resulting from their respective reviews, and 3) responses provided by the principal investigators to the peer reviewer panel to their submitted questions and comments.

## Risk Assessment and Mapping Program (RAMP) Peer Review Questions

### Question 1:

**Do you have any technical criticisms of RAMP for non-native species risk assessment? If so, what recommendations do you have for modifying RAMP to be used in climate matching for non-native species risk assessment?**

*Comment 1: RAMP is an excellent tool: however, it would be advantageous to let the user design the experiment by allowing the addition of external data (points or polygons) as necessary, i.e., a more flexible system. We tried to input some external data and it was not easy for us to access the geodatabase.*

*In its current version, RAMP seems too rigid if the user has additional data points, regions or other climate layers. GBIF data is only one option and has the known issue of often having errors associated to the data (taxonomic, geographic, etc.), which could potentially harm the results given by RAMP.*

**Response 1:** The spatial resolution in RAMP is currently fixed and cannot be modified by the user. A finer grained resolution was not incorporated over a continental scale in RAMP, as the time to process results (individual matches) would have proven detrimental to the user experience, and resulted in reduced ability of the program to serve as an effective decision-support tool for managers conducting expedited risk analyses for numerous individual species.

Finer resolutions could be used on smaller geographic scales (e.g. Great Lakes basin or individual States/Provinces). Currently, an individual user can add additional data points to aid in selections of source locations (global locations to be matched with North American locations) for their use in conducting a specific analysis. In RAMP, eight target regions can be matched against global source data: United States, Canada, Mexico, Great Lakes Basin, Central America plus Mexico, Caribbean, Continental United States, and North America. RAMP was developed using the same 16 climate variables, climate matching algorithm, and scoring that was developed, tested, and used to match climate for freshwater fishes and other vertebrates (Bomford 2008, Crombie et al. 2008). RAMP is designed to use GBIF Data as a starting point when performing a match on a species. It is recommended that users verify and add or remove locations from the pre-selected stations, as needed, for their desired analyses.

**Comment 2:** *What considerations have been taken into account to model aquatic or marine species as even if continental climate layers are useful to develop models, the conditions in the water can be very different?*

**Response 2:** Regarding considerations that have been taken into account, RAMP was developed using the same 16 climate variables, climate matching algorithm, and scoring developed, tested, and used to match climate for freshwater fishes and other vertebrates (Bomford 2008, Crombie et

al. 2008). Climate matching using those variables, algorithm, and scoring, along with history of invasiveness, which is used along with climate matching in USFWS Ecological Risk Screening (U. S. Fish and Wildlife Service 2014) are summarized as follows (from Bomford 2008).

RAMP has not been developed for use in assessing climate niche for marine species. However, we have developed a tool for marine species climate and habitat match. That tool will be peer reviewed prior to finalization.

- “Overall, results showed there are four key factors for which there is strong evidence of a correlation with establishment success:
  1. Propagule pressure — the release of large numbers of animals at different times and places enhances the chance of successful establishment.
  2. Climate match — exotic species have a greater chance of establishing if they are introduced to an area with a climate that closely matches that of their original range.
  3. History of establishment elsewhere — a history of previous successful establishment is a strong predictor for all vertebrate taxa.
  4. Taxonomic group — species that belong to families and genera that have high establishment success are more likely to be successful than other species, all else being equal.”

Furthermore, the climate matching conducted by USFWS was independently tested (Keller and Lodge, unpublished report). The methods and results of that testing are summarized below.

- Methods:
  - “Climate Match: We assessed climate match for the 154 species in three ways. In all cases we determined the level of match between the current non-US range of the species and the U.S. 48 states (i.e., excluding Alaska and Hawaii). Latitude overlap, Climate 6, and RAMP were used as the alternative measures of climate match. The former was tested because it can be determined very rapidly (i.e., in minutes for most species). The latter two measures require some expertise with relatively basic software programs, and take from ~15minutes – 2 hours per species. Details for each are below.
    - First, we determined whether there is a latitude overlap between the current non-US range of the species and the U.S. 48 states. This can be rapidly determined and gives a simple binary (overlap or not) result for each species.

- Second, we calculated Climate 6 scores (see Bomford 2008 for a description, software available at <http://data.daff.gov.au:8080/Climatch/>) for all species. This score ranges between 0 and 1 with higher scores indicating a higher climate match. To obtain a binary response from this continuous variable we designated all species with a match greater than 0.005 as being ‘positive’ for this measure (i.e., species with a climate match of 0.005 or below were designated as ‘low risk’).
- Third, we calculated RAMP scores for all species between their current range and the lower 48 states. This score also ranges between 0 and 1 with higher scores indicating a higher climate match, and again we used 0.005 as our threshold. RAMP software has recently been developed by USFWS and is not yet widely available.”
- Results:
  - “Our Tier 1 risk assessment tools are based entirely on a species’ climate match and history of non-native establishment elsewhere. We assessed and tested climate match in three ways. First, we tested the very basic approach of comparing the latitude range in which the species currently exists to the latitude range of the lower 48 U.S. states. Ideally we would have used the latitude range of the species at the time it was first discovered in the US, but historical range data are not available. Second, we used Climate 6 as a measure of climate match. Climate 6 scores were generated by USFWS Region 3 and compared the current known range of the species to the lower 48 U.S. states. Finally, we used RAMP scores, which were also generated by USFWS Region 3 .... we believe that our results provide strong support for the USFWS SOP as applied to freshwater fish introductions to the lower 48 U.S. states. This approach would have had high accuracy both for identifying non-establishers as Low Risk, and for identifying species that now have impact as High Risk. Species that have high impact and have spread the most would have been classified as High Risk most often. The RAMP climate matching tool performed slightly better than Climate 6, and may be an appropriate replacement to the latter for the SOP.”

**Comment 3:** *A suite of results where Euclidean distances are one option, but they are not the only one. In order to support decision making, we also suggest the use of other distances such as Mahalanobis, where covariances among environmental predictors are considered.*

**Response 3:** In RAMP, normalized Euclidean distance was incorporated as the algorithm because its use has been previously tested and demonstrated as effective for assessments of

fishes and other vertebrates (Bomford 2008). Our use of normalized Euclidean distance has been independently tested, and has been found to accurately categorize risk of 154 species of fishes introduced into the United States (Keller and Lodge, unpublished report).

**Comment 4:** *Overall, RAMP is easy to use. The tool could definitely be streamlined into an online interface, or even be a two-step ArcTool process. I do have a few minor comments and requests for documentation changes and additions. The only place in the documentation that states where the source occurrence records are from is in Step 1 of “Using RAMP”; there should be a section in the documentation devoted to explaining these data and limitations. In the actual tool, it would be convenient if the possible source species were available through a drop down list, organized by categories (e.g., plants, mussels, fish, etc.). Also, RAMP does not compensate for low number occurrences versus establishment of a species. A useful addition would be to include a way for the users to filter out single occurrences for a given grid cell. Please edit the documentation reference to “ArcIMS” in the Future Enhancements section.*

**Response 4:** To simplify and streamline RAMP’s usability, vestigial documentation will be removed for the final web-based version made available on the internet (when RAMP was first developed, ArcIMS was still in service). It is possible to implement a drop down species for use in RAMP. While this would be practical for use with a few species, the inclusion of hundreds of species into the drop down list would become increasingly time consuming less efficient as compared to simply manually entering the species name. In the web-based version, the species name would not need to be entered more than once. FWS has developed and uses a Standard Operating Procedure (SOP) for quality assurance/quality control (QA/QC) of source data points. That process was not peer reviewed, but will be made available as an appendix to the RAMP User’s Guide. RAMP is currently structured as a three-step process by design. A primary reason for this is to provide the user the ability to “batch” and create species profiles and folders. In the first step, the user can batch a list of species, then perform the selection and match in the second and third steps, respectively. A web based version would most likely consist of one step for either a species or performing a match with hand-selected data.

**Comment 5:** *The process for running a species in RAMP is simple and straightforward; however, the second step “Get Species Pre-selection” is a lot of clicking to get where you need to go. I would recommend shortening the amount of steps to get to the data you need; and also perhaps renaming that step to something more descriptive to the process such as “Define Source or Donor region”. Is there a way to shortcut directly to the “Points” folder for the species you have chosen?*

**Response 5:** A shortcut to obtain species points has been implemented in RAMP. Typing in an individual species name will automatically select the points from that species profile. Steps one and two could be consolidated into one process; the reason they are currently separated is to potentially batch-process species at one time. “Get Species Pre-selection” now implements the

species' scientific name for entry, as well as the pre-existing method of "file browsing". A web-based version would be simplified to entering an individual species name a single time.

The "Get Species Pre-selection" function has been modified to use the scientific name or browsing to the file. Points automatically selected during this step are to be used as a guide when performing a match. As currently designed, RAMP allows the user to modify the selection before the match is performed during step three. A web-based version of RAMP will not require this step.

**Comment 6:** *In Step 3, it's repetitive and inconvenient to retype the scientific name into the box. Could this be a dropdown box for the species that have already been defined within the profiles folders?*

**Response 6:** A drop-down method could be implemented in RAMP. However, it was felt that typing, or copy and pasting, a species name for use would lead to fewer errors as compared to using a drop-down menu (i.e. accidentally selecting wrong species). A web-based version of RAMP will not require this step.

**Comment 7:** *I was concerned about the speed of the tool, but the newer version (Ramp 2.7) provided runs much faster under the current scenario and is much more feasible for use. It still ran a little slow for some of the projection scenarios however. In one run it took about 25 minutes, so it would be ideal if this process could be quicker. It would be valuable to have a tool that could be used to select a particular region of points and collect data for just those points (you wouldn't have to develop a specific RAMP for each individual state, you could just select the state you are interested in, and run the points down to that level). Alternatively, you could have a pre-selection of each of the state's points and make them available in the drop down menu on Step 3. Although this is included in the future plans, I would like to stress the importance of having a web-based version of this tool (I had to purchase a newer ArcMap version to be able to run the tool at a cost of about \$300). If a state agency or resource manager does not have the correct version of ArcMap, with limited resources they are unlikely to spend the money to obtain it, and then the tool is subsequently not usable for them. In the online version, I would also provide an option to show state/provincial boundaries. It was mentioned in conversation a principal investigator that multiple species could be run at one time. It would also be useful to be able to run one species under multiple RCP's or time periods at one time to be able to quickly compare changes in species climate suitability over time. In the outputs, .DBF and .CPG weren't recognized file extensions on my computer. Could these be changed to something more universal for Excel?*

**Response 7:** The DBF files can be opened in all recent versions of Microsoft Excel, and a CSV file will be generated by RAMP as an output to compliment the DBF file. During testing of RAMP, a CPG file was never generated/encountered by the program. Once we were made aware of the CPG file type being created, we tested various schemes in an attempt to generate a CPG

file. Under further investigation, the generation of the CPG file type could be due to cancellation of the script before it was completed. Plans are to make the RAMP source code and framework available to download, by individuals submitting a request to FWS, so that users can develop and utilize their own target layers. The ability to run multiple RCPs/generations for a single species will be incorporated within the upcoming software-based (ArcMap) version of RAMP.

## **Question 2:**

### **Current Climate Data**

Current climate data were obtained from datasets hosted by Worldclim.org (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005). “The data layers were generated through interpolation of average monthly climate data from weather stations on a 2.5 arc-minute resolution grid (often referred to as "5 km<sup>2</sup>" resolution). Variables included are monthly total precipitation, and monthly mean, minimum and maximum temperature, and 19 derived bioclimatic variables.” We used 16 of the 19 bioclimatic variables to predict similarity.

**Do you have any technical criticisms of the current climate data used in RAMP? If so, what recommendations do you have for modifying RAMP?**

**Comment 8:** *We understand that some bioclimatic layers are highly correlated; however we would like to know the criteria used to select the 16 variables.*

**Response 8:** Please see the response to Comment 2.

**Comment 9:** *It should be assumed that whoever is using this tool is not familiar with WorldClim data, (therefore) the date range of data available should be clearly stated (1950-2000). The last 14 years have experienced the most noticeable changes due to global warming and are not reflected in this dataset. I would say this is a technical criticism as well, but I do not believe there is a way to improve the input climatic dataset at this point. It would be helpful to include a list the 16 variables you are utilizing in the algorithm from the BIOCLIM data and a brief statement of why 3 of the variables were not included.*

**Response 9:** The 16 variables were tested by Bomford (2008) and are used in CLIMATCH (Crombie et al. 2008). We used the approach tested and peer reviewed by Bomford (2008) and Crombie et al. (2008). We do not know why the other variables were not used by those authors. Three variables related to temperature were not used. These variables and associated BIOCLIM codes are Mean Diurnal Range (BIO2), Isothermality (BIO3), and Temperature Seasonality (BIO4). The 16 variables used are copied from Crombie et al. (2008), and shown here:



**Match Settings:**

**Species:**

**Algorithm:**  
 Euclidean    Closest Standard Score

**Variables:**

<input checked="" type="checkbox"/> Annual Mean Temperature	<input checked="" type="checkbox"/> Mean annual rainfall
<input checked="" type="checkbox"/> Temp - coldest month	<input checked="" type="checkbox"/> Rainfall - wettest month
<input checked="" type="checkbox"/> Temp - warmest month	<input checked="" type="checkbox"/> Rainfall - driest month
<input checked="" type="checkbox"/> Annual temperature range	<input checked="" type="checkbox"/> Coefficient of variation - rain
<input checked="" type="checkbox"/> Temp - coldest quarter	<input checked="" type="checkbox"/> Rainfall - wettest quarter
<input checked="" type="checkbox"/> Temp - warmest quarter	<input checked="" type="checkbox"/> Rainfall - driest quarter
<input checked="" type="checkbox"/> Temp - wettest quarter	<input checked="" type="checkbox"/> Rainfall - coolest quarter
<input checked="" type="checkbox"/> Temp - driest quarter	<input checked="" type="checkbox"/> Rainfall - warmest quarter

 

**Comment 10:** I would like to note in the above statement and in the documentation under “Data Sources and Construction/Current” section you describe the resolution as “5km<sup>2</sup>” which needs to be corrected. Typical nomenclature is “5km” to mean grid cells of 5 km x 5 km (which actually equals 25 km<sup>2</sup>).

**Response 10:** This has been corrected and the description for grid cell size is now for 25 km<sup>2</sup>.

**Question 3:**

**Future Climate Data**

Future climate data was obtained from datasets hosted by Worldclim.org (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005). Two generations were used: 2050 and 2070. Outputs from Global Climate Models (GCM) were used and interpolated using an identical method to the current climate data to produce the necessary data.

**Do you have any technical criticisms of the future climate data used in RAMP? If so, what recommendations do you have for modifying RAMP?**

**Comment 11:** Please see earlier comments.

**Response 11:** Please see earlier responses.

**Comment 12:** *I do not have any technical criticisms of the GCM data included. I believe the two years are 2050 and 2080 according to the WorldClim website.*

**Response 12:** No response.

**Comment 13:** *For my purposes it would be useful to have more than just two future climate scenarios. Potentially look into additional climate data besides Worldclim; for example, data available at: [http://gdodcp.ucllnl.org/downscaled\\_cmip\\_projections/dcpInterface.html](http://gdodcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html) goes up to 2099.*

**Response 13:** We are using the only two generations currently provided by WorldClim 2050 (average 2041 - 2060) and 2070 (average 2061 - 2080). Other data could be used, provided it contains all 16 variables for the target location. However, we are not currently adding additional generational data to this version of RAMP.

#### **Question 4:**

##### **Climate Matching Algorithm**

The algorithm used for climate matching is that developed and published by the Bureau of Rural Sciences (2006).

**Do you have any technical criticisms of the algorithm developed and published by the Bureau of Rural Sciences (2006) and used in RAMP? If so, then what recommendations do you have for modifying RAMP?**

**Comment 14:** *The idea of distribution modeling (SDM)/ecological niche modeling (ENM) has been already implemented in the fields of species. However, what makes RAMP different is its user friendly interphase which helps the user to obtain a broad comparison between different areas.*

*A disadvantage is that it is implemented on software that is not accessible for many users concerned with either native or non-native species, even less when the license needed to run it has to be the most recent version. For this reason, we recommend moving this tool to some open source platform like Quantum GIS.*

**Response 14:** We have not explored the feasibility of moving RAMP to an open source platform. However, as all of the scripts included in RAMP are written in a format that would accommodate this action (Python language), it should be relatively straightforward to modify the current version to allow it to be used with Open Source software and made available via the internet.

**Comment 15:** *I do believe this is one of the most widely accepted algorithms in place currently, and until the common computer and user can utilize machine learning algorithms, this is a very safe algorithm.*

**Response 15:** No response to the comment.

**Question 5:**

**Global Climate Model**

The model chosen for the future similarity predictions is the Geophysical Fluid Dynamics Laboratory's Couple Physical Model 3 (GFLD-CPM3).

**Do you have any technical criticisms of the global climate model used in RAMP? If so, what recommendations do you have for modifying RAMP? Do you recommend any additional models be added, in addition to the GFLD-CPM3?**

**Comment 16:** *No comment.*

**Response 16:** No response.

**Comment 17:** *I do not have any technical criticisms of the global climate model used in RAMP.*

**Response 17:** No response.

**Comment 18:** *No comment*

**Response 18:** No response.

**Question 6:**

**Representative Concentration Pathways**

RAMP has the ability to predict similar future climates in line with three Representative Concentration Pathways (RCPs). These include RCP2.6, RCP4.5 and RCP8.5. The RCP6 pathway was not available with the chosen model.

**Do you have any technical criticisms of the RCPs used in RAMP? If so, what recommendations do you have for modifying the RCP use within RAMP?**

**Comment 19:** *It is not clear what you mean by Representative Concentration Pathways (RCPs). We would need more details in order to give our opinion. Is this already available in the current RAMP version?*

**Response 19:** The current RAMP version includes three RCPs. RCPs are a new system of scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) that were released in late 2013. Additional information on RCPs can be found at:

<http://www.ipcc.ch/pdf/supporting-material/expert-meeting-ts-scenarios.pdf>

- [IPCC explanation of why RCPs were created](#)

<http://www.theguardian.com/environment/climate-consensus-97-per-cent/2013/aug/30/climate-change-rcp-handly-summary>

- [Guardian summary of RCPs](#) (“Now available: a guide to the IPCC's new RCP emissions pathways”)

<http://www.ipcc.ch/pdf/supporting-material/expert-meeting-ts-scenarios.pdf>

- [Scenario development from SRES to RCP](#) (“Towards New Scenarios for Analysis of Emissions, Climate Change Impacts, and response Strategies: Technical Summary of the Intergovernmental Panel”)

**Comment 20:** *It would be helpful to have more documentation available in the tool or in the official documentation describing what the RCP values mean.*

**Response 20:** RCP descriptions and additional relevant technical information will be added to the RAMP tool descriptions sidebar. (Note: please see Response 19 for additional context and rationale on use of RCPs in RAMP).

**Comment 21:** *I would like to be able to do a comparison study with previous climate change and AIS research. However, this study used the older IPCC emission scenarios instead of the RCPs. Is it possible to have the older scenarios available as options; or be able to load them into the program for such purposes if needed along with the more current RCPs?*

**Response 21:** We have stopped technically supporting the IPCC SRES emission scenarios recommended for use in the past and are fully supporting IPCC RCPs (IPCC 2013). Upon request, USFWS will provide code and data for the previous generation of RAMP.

### **Question 7:**

#### **Downscaling Method**

Downscaling of the GCM to a resolution suitable for RAMP was performed by WorldClim 1.4. More information on how this data was generated is available from worldclim.com.

**Do you have any technical criticisms of the downscaling used in RAMP? If so, what recommendations do you have for modifying the downscaling approach use within RAMP?**

**Comment 22:** *It would be useful to allow users to create their own layer set either by using available data sets like Worldclim or some created ad hoc.*

**Response 22:** Individual users will be able to use external data for future scenarios. Source code and construction tools will be provided, upon request to USFWS, which would allow users to modify RAMP to suit their individual needs. Users can then modify the source code with user-provided data and construct a version of RAMP suitable to their specific needs.

**Comment 23:** *Downscaling climate data is an interesting thing because we don't actually know what is occurring between observed locations. Elevation should be taken into account when downscaling, and would be a way to improve this model, though the actual observed stations are dense enough within the United States to provide confident results, this should be a caveat if used for predictions elsewhere on the globe. An interesting person to discuss this aspect with would be Chun-Mei Chiu at Notre Dame. She is a post-doc working with optimizing downscaling of climate data in the Great Lakes Region. She has developed quality control/assurance procedures into her process.*

**Response 23:** In its current version, RAMP will not directly account for and incorporate elevation in the model. Though elevation is not part of the climatic variables currently used in RAMP, its effects on climate will be taken into account in future versions, although actual measured elevation will not be explicitly used. Instead, large variations in climate over short distances, such as climatic changes corollary to changes in elevation, will be incorporated in a future version of RAMP. The density of source stations in areas with high climatic variability will likely be increased in the future, thereby increasing the ability to accurately capture these changes.

**Comment 24:** *No comment.*

**Response 24:** No response.

### **Question 8:**

#### **Climate Station Construction**

For the construction of the Global (Source) and North American (Target) climate stations data was used from datasets available on Worldclim.com (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005). Using climate stations available from various different climate databases Hijmans et al. produced an interpolated, continuous, climate data across the globe at 30 arc-second resolution for current climatic conditions.

The Global layer consists of a grid of equally spaced points across the globe. Each of these points can be considered a climate station and represents the current climate for its location. The North American layer consists of a grid of equally spaced points across North America. North American points contain both current climate data as well as data for potential future conditions.

Climate model outputs were applied to points for both the Global and North American layers in the same fashion. The only difference is the spacing: Global points were generated in a grid 75.9km and North American points are separated by 15km. These points become pseudo climate stations once the allowing a match to be performed.

To obtain climate data for Global and North American layers Worldclim rasters were used. This covers the landmasses at a scale of 2.5 arc-minute or a "5km<sup>2</sup>" grid. Raster values were applied

to Global and North American layers using Arcmap's "Extract Multi Values to Points". Bilinear interpretation was also used to limit any raster anomalies.

The resulting layer's field names were corrected and values were converted to non-integer, real world, values.

**Do you have any technical criticisms of the climate station construction approach used in RAMP? If so, what recommendations do you have for modifying that approach?**

**Comment 25:** *This is a very general approach and the level of resolution/detail depends on the region of the world and density of weather stations available. However, most approaches depend on interpolations like those used here. A recommendation would be to let the user include more information into the system as it becomes available.*

**Response 25:** The goal of the RAMP project is ultimately to provide an online real-time, decision-support tool that is widely available to and utilized by resource managers, scientists, and others for evaluating potential risk of invasion by select species under specific climate scenarios. The RAMP will be updated and revised periodically to integrate necessary changes and new developments relevant to the program. Once RAMP is made available via the USFWS website, individuals can request source code from the principal investigators. Climate data will continue to be served via WORLDCLIM. Individual users may use additional data in their modification of RAMP, if they so desire. In addition, RAMP was developed using the same 16 climate variables, climate matching algorithm, and scoring that were developed, tested, and used to match climate for freshwater fishes and other vertebrates (Bomford 2008, Crombie et al. 2008). Climate matching using those parameters, as well the history of invasiveness, which is used along with climate matching in USFWS's Ecological Risk Screening (U. S. Fish and Wildlife Service 2014), are summarized in earlier sections of this summary

**Comment 26:** *I feel as though the density of climate stations is at a threshold which optimizes computer processing and resolution of results. As stated in Question 7, it would be great to improve on this work by adding in an elevation regression, but is probably out of the scope of this particular project.*

**Response 26:** No response.

**Comment 27:** *No comment.*

**Response 27:** No response.

**Question 9:**

**Point Spacing and Climate Niche**

RAMP uses points that are equally spaced to predict the climate niches.

**Do you have any technical criticisms of the equally spaced points to predict climate niches?**

**Comment 28:** *See previous comments.*

**Response 28:** See previous responses.

**Comment 29:** *The resolution is rather coarse so many unique niches will be missed, but I view this tool as an initial analysis to determine if a species has a chance of establishing and further ecological niche modeling would be implemented at a finer scale. I believe the output would be easier to visually comprehend if the points were converted back into raster format.*

**Response 29:** RAMP was designed as a decision-support tool that would supplement and further inform the use of the Rapid Risk Assessment, an evaluation process developed to provide broad-scale, expedited assessments of the potential risk of introduction for individual species on a continental scale. The results generated by RAMP modelling provide insight as to the need for further investigation with other available analytical tools. The principal investigators had previously discussed reverting back to a raster format prior to the RAMP peer review. However, it was determined that points would be maintained to represent scores to limit the ability of geographically-specific results. The use of rasters is being considered for future versions of RAMP to increase processing speed for modeling different scenarios.

**Comment 30:** *No comment*

**Response 30:** No response.

**Question 10:**

**Utility of RAMP for Nonnative Species Risk Assessments**

RAMP was constructed to provide climate matching of species climate niches, for the U.S., Canada, and Mexico. Obviously, our main geographic focus is the U.S., but we include the other North American countries so as to allow continentally based decision support for nonnative species risk management. Our needs for RAMP also included climate matching under present and projected future climates.

**Does the existing version of RAMP supply a tool that is useful and defensible for nonnative species risk management decision support? If not, do you recommend: 1) RAMP not be used in non-native species risk management? or 2) any specific modifications to RAMP?**

**Comment 31:** *We think RAMP is a useful tool in identifying areas where non-native species could potentially become established based on climatic similarities. We don't think it can be used by itself, to make a decision, but rather as part of a more complete risk assessment which takes into account other factors such as habitat characteristics or the invasion process. As mentioned earlier we think it is important to allow the use of additional data (both climatic and*

*specimen), and not only use GBIF as a data source, despite it is expected to be the most complete source of data.*

**Response 31:** We agree that climate matching cannot be used alone to assess risk of nonnative species. Climate matching is used along with history of invasiveness, in Fish and Wildlife Service’s Ecological Risk Screening (U.S. Fish and Wildlife Service 2014), which has undergone peer review and results are publically-available at <http://www.fws.gov/science/pdf/ERSS-Peer-Review-Response-report.pdf>. Our Ecological Risk Screening is based on peer reviewed results published by Hayes and Barry (2008) and Bomford (2008), which support climate matching and history of invasiveness as a risk assessment process that is scientifically based and defensible.

**Comment 32:** *The “Target” results shown in the map document are 0 to 10 and lead the user to believe that 7-10 are areas that are highly likely for the target species. It would be nice to create descriptors for the levels or ranges (e.g., extreme, very high, high, low, etc.). The documentation and reference make this method a very defensible method for supplying information regarding nonnative species risk management.*

**Response 32:** Qualitative descriptors of “Low” and “High” have been incorporated into the legend within RAMP. In the current version of RAMP, whole numbers rather than qualitative descriptors were intentionally used to provide more fine-grained results on a gradient, and to limit the use of “absolute” style descriptions. A legend will be added to the RAMP documentation in future versions to provide more complete information and context relative to a species potential to invade.

**Example:**



**Comment 33:** *Yes, I feel the RAMP tool is highly valuable and important for performing proactive risk analysis on species especially in the wake of climate changes. As mentioned above, for Pennsylvania this tool would be even more valuable if a small selection of points within the map were able to be selected to run analysis to get down to a finer scale for specific state management purposes and to support early detection goals outlined in the State AIS Management Plan. Even without these changes, the tool as it is will give insight into species that pose a risk now, and into the future. During my review of RAMP, a species in the genus *Pterygoplichthys* was discovered in a creek near a thermal discharge in Montgomery County, PA. The species was suspected to be an aquarium release that most likely wouldn’t survive the*



*winter. I immediately opened RAMP and ran the species in various scenarios to compare climate suitability and determine if, over time, this is a species that if continued to be released would eventually be able to establish in Pennsylvania waters. This kind of information is extremely important in making management decisions and prioritizing species and focusing limited resources.*

**Response 33:** The RAMP model was developed for conducting analysis at the national and continental scales within North America. Development of a finer-scale version of RAMP is possible, and a resolution of approximately 1km attainable, with data currently available. To allow for development of RAMP at various scales, source code and construction tools will be provided to individuals, upon request, by USFWS. Users can then modify the source code with user-provided data and construct a version of RAMP suitable for conducting their desired analyses and address specific resource management questions of interest to their region or jurisdiction.

## References:

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