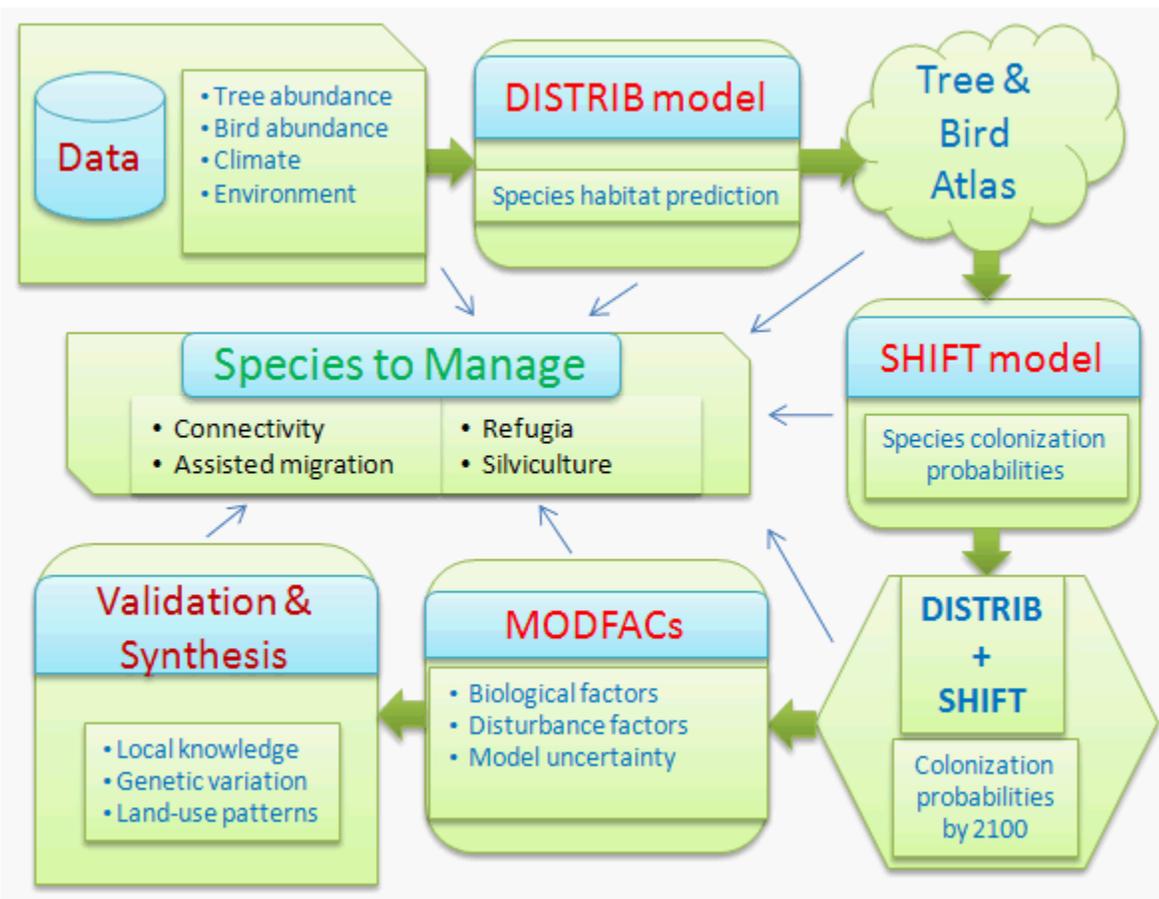




Assessing the impact of climate change on tree and bird species - a multi-stage modeling approach

As the influence of altered climate conditions continue to emerge and species respond to these changes, managers need to explore potential scenarios related to the suitable habitat of tree species. Our approach uses a multi-stage approach with 1) DISTRIB, which predicts potential suitable species habitats under current and future climates. The results of this model can be explored via the Tree and Bird Atlas, and are the focus of the questions below; and 2) SHIFT is then used to determine how likely species are to colonize new suitable habitats (not yet implemented in the atlas). In addition to these models, 3) a scoring system known as ModFacs (Modification factors) can be used to look at how outside disturbances or biological factors might influence the future distributions of these species. The schematic below shows the flow of data to each model and how output can be used to examine the potential responses of climate change.





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Climate change tree and bird atlas – what are some basic outputs from the atlas and what are some features of this tool?

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We prepared some background material and a series of questions that one might want to ask related to the trees of the eastern United States, and some possible fates of their suitable habitats based on climate change scenarios. We hope that following along with these questions will allow a quick way to become familiar with the rich information contained in the atlas. You can navigate also with the “You are here” breadcrumbs at the top of each page. There are also  buttons on most pages for help.

1. We have several **Climate Change Atlas Videos**, outlined on the lower right panel, that clearly explain how the atlas works – see the lower right portion of front page for these, and each are about 4-6 minutes in length.
2. Across the bottom of the page are links to many pieces to the atlas. For a brief outline on how the models work and the approach we use, go to ‘**Learn about the Models**’. It gives you a brief overview of the modeling process, including DISTRIB, SHIFT, and ModFacs, along with key citations if you wish to dig deeper. For this updated version of the atlas, we have added information on ModFacs to the DISTRIB work, but we still don’t have SHIFT outputs available. ModFacs allows for consideration of biological and disturbance factors that affect species distributions, things we cannot readily model such as insects and disease and the like. The ‘Adaptability’ factor is an index factor taking biological and disturbance factors into account and is related to how well the species may cope with a changed climate in the decades to come.
3. We can always use the breadcrumb at the top of each page to navigate around the website as well.
4. There are also two parts featured on the front page to peruse: ‘**Featured Research**’ which shows a recent research product that uses these data and ‘**Combined Species Outputs**’, which shows some ways to address multiple species combinations. We will get to some of that later.
5. OK, now to get to information for individual species. The upper right box provides multiple ways to obtain species of interest. You can type in a portion of the scientific or common name or the FIA number, or click on ‘**List of Trees**’ or ‘**List of Birds**’ to get a table that can be sorted on FIA number, model reliability, scientific name, and common name to help locate species of interest.
6. Let’s type ‘oak’. We get a list of the oaks in the database. Click on ‘white oak’. Then you see the names and the model reliability. We have 3 classes of **model reliability** – like the Dept of Homeland Security – so green is good and red is bad. Bad models are usually uncommon species with not quite enough data to support a good model. So they have more uncertainty. Pay attention to this when interpreting data! Click on the highlighted blue species name.



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7. Right panel: Please see the **Cautions and model info** section in the upper right panel, and at least scan that material. [NOTE: to exit pages launched from the home pages, click the ‘X’ on lower right of panel]. It initially provides information on how to cite the atlas and key papers that provide support for the atlas information. Next, we want you to be fully aware of caveats of what the atlas can do and **especially what it cannot do**. We have been burned many times by people extending the interpretation beyond what we report – the main problem is when people think the species will be (or not be) at new locations by 2100 when we have a map projecting new suitable habitat (or habitat loss) for an area of interest. Then, we provide some **Frequently Asked Questions**, and answers. Next, there is a button-notice that you can go back to the **previous atlas** if you are used to that.
8. Next, ‘**about white oak**’ gives some basic information on family, guild and lifeform, and links to **life history and disturbance response**, **silvics manual** pages, photos and links to all the information in the **USDA NRCS Plants database**, and a way to download the data for the species into **Google Earth**.
9. Next expand the ‘**Climate Change Adaptability**’ section. Here’s where we provide information on the ModFacs, or modification factors. Clicking on ‘MODFACS’ highlight will provide the data in ‘bubble’ format on 9 biological characteristics and 12 disturbance characteristics. For white oak, we give ‘green’ ratings for biological and disturbance characteristics overall (so it is quite adapted to climate change, with an overall score of 6.1 out of 8.5 possible), but we rank negative for insects and disease. If we go back and search for white ash, and go to its ModFacs, it is scoring only a 2.7 on the adaptability scale with of course a large negative for EAB. If you want to know more about ModFacs, we have a whole paper on that (see **Cautions and model info** section).
10. Going one more tab lower on the right gives “**Summary of Predicted Changes**”. This section has a piece on **Mean Center of Distribution** and **Summary Change Maps**. For Mean Center, it shows the ‘center of gravity’ and a distribution ellipse for the current distribution and potential future suitable habitat within the eastern US. The Summary Change maps have two tabs, one which shows current and potential future distributions, and one which shows potential change maps for current FIA, modeled current, the mild PCM B1 scenario, the harsh Hadley A1FI scenario, and average of 3 low and high scenarios.
11. Next are ‘**Range and Niche Maps**’, with many maps of Range with and without the Little’s boundaries and the inclusion of Canada. Under Niche Maps, we show on the right the same distribution map with various colors representing the current importance values, or abundance of the species, and on the left, a niche map that shows where those same importance value colors fall on a graph of mean annual temperature vs. precipitation. The gray represents the temperature and precipitation throughout US and Canada south of the 60 degrees latitude line. The other tables provide similar graphics for elevation and soil, and for the US only.
12. Next, is the ‘**Predictor Analysis**’ tab with many, many graphs and tables intended to allow the user to get into the nitty gritty on the variables we used and how they relate to the current distribution of the species. **Predictor Statistics** has many graphs showing the importance of various variables in comparison to the variable importance across all species. **Predictors Importance for white oak** shows the importance of various predictors for the model, in ranked order. In **Geographic Predictors Map**, we show a modeled ‘tree’ of the regression tree analysis and at the bottom of the tree, the ‘nodes’ which are then mapped under ‘Class Map’. So it shows what variables are influencing the current distribution at various parts of the country. This map is not so trustworthy though if the Model Reliability is not high, or green.
13. Now for the main section of the page, the **Current Distribution Maps for white oak** piece. We can look at the current FIA map or current modeled map (with the pull-down menu). The current modeled



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map is smoothed. If you wish to compare two species, you can click the button in upper right, then punch in another species name and hit 'update maps'. Then you can swipe the bar (go to middle of map for bar) across the map to show both species. You can hit '**Statistics**' to show the percent of the eastern US that is occupied by both species, the average importance value when present, and the sum of the importance which accounts for both area and average importance. The basic statistics for the map shown also appears at the bottom of each map.

14. Next, skip over to the '**Predictor Maps**' tab, which presents the predictors used for white oak in ranked order on the pull-down menu. And you can use the **Compare Predictors** button to compare two predictors with the swipe feature. For example, if you use Forest land % vs. Cropland % and you can see they are inversely correlated.
15. Finally, click on the '**Projected Future Habitat**' tab which defaults to show the most 'harsh' scenario – HadleyCM3 – A1FI. The drop-down menu allows eight choices of scenarios or combinations of scenarios. If you hit '**Compare Scenarios**', you can compare two scenarios side by side with the swipe function. It is most common to compare the 'Current modelled' to one of the future scenarios. If you compare first PCM B1 (a mild scenario) to Current modelled, there is not much change as compared to comparing Hadley A1FI (harsh) to the current. Again, hit '**Statistics**' to get a summary of all potential changes in % Area Occupied, Average IV, Sum IV, and the ratio of Future:Current Modelled Sum IV. In this last case, any ratio above 1 is a projected gain in suitable habitat, while a ratio below 1 is loss in suitable habitat across the eastern US. Clicking on '**Multiple Maps**' allows you to select from a set of available maps and at 3 different map sizes corresponding to one, two, or three maps across the page. These maps are often screen dumped for presentations.
16. Hit 'back' or use breadcrumbs to get back to a main page. Now scroll to bottom of page. **Products**. First 'Publications' shows quite a few publications, dating back to 1998, which shows the progression of work going into the atlas, and some of the products from this work.
17. Then **Regional Assessments**. Here is where we put detailed information that was prepared in conjunction with the NIACS group – especially Leslie Brandt, Maria Janowiak, Stephen Handler, Patricia Butler, and Chris Swanston as part of their Climate Change Response Framework. We have data for five regions - the Northwoods, the Central Hardwoods, the Central Apps, New England, and the Mid Atlantic. We provide a link here that is a guide to interpreting the tables, in which we classify each species into 1 of 8 classes ranging from extirpated to decrease to no change to increase to new entry of suitable habitat under most any scenario of climate change to new entry only if the climate changes severely. There is a series of pdf or excel tables for each region and sections within the regions. There are also a series of US Forest Service General Technical Reports (GTRs) either out or in process on these vulnerability evaluations by NIACS (see the publications section). Clicking on the '**Interpreting Regional Assessment Tables**' brings up some slides that explain each column in these large tables with northern Minnesota as an example. First, the **FIA number** of the species, followed by the **Common Name** with colors of **Model Reliability** which should always be taken into account when interpreting the tables. Next, are the **FIA** and **Current Modeled** estimates of Sum IV for each species – the average abundance of the species multiplied by the number of cells in the assessment area where the species has been found or modeled to be found. The **Modeled IV in Future** shows projections of Sum IV for three time periods ending in 2039, 2069, and 2099 and for two scenarios – the PCM B1(mild) and the GFDL A1FI (harsh). The Future Sum IV numbers are then divided by Current Model Sum IV to get the **Future:Current Ratio** where 1 means no change. *Remember, we are not suggesting that the species will be there at these time intervals – only that we model that the habitats will be suitable for the species.* These ratios form the basis of the **Change Class** ranking into 1 of 8 classes mentioned before. If



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the species is rare, there are more stringent rules. Then we provide the most important **Modifying Factors**, either negative or positive, followed by the overall **Disturbance Factor** score, the **Biological Factor** score, and the **Adaptability** score for the species. If the Adaptability score is orange, we might expect the species to do roughly as suggested by the habitat models, if green, better than modeled, and if red, worse than modeled.

18. Either at bottom of page or at opening page is a section titled ‘**Combined Species Outputs**’. This section needs to be updated but the older data is presented. We wish to update to make sure that at least 40 20x20 cells are represented by each locality for reasonable outputs. Click on “**Modelled Future Habitats**” tab followed by “**Potential Species Winners and Losers in National Forests/Grasslands**”. Then click on your NF (for example, the Monongahela). You can sort any column but initially sort by ModCur (click twice to get large to small sort) to get sorted list of species by average IV. This will be updated to Sum IV in the future update so it is in line with other data, and our preferred way to evaluate the numbers. For now, adding ModCur with the Difference data provides estimate of future habitat, for example quaking aspen has average importance of 21.8, but with high emissions under Hadley, add - 17.41 for a reduced importance of suitable habitat to 4.4 in future.

A few questions you might want to ask of the data:

Climate and Other Predictor Questions

1. *What range of temperature conditions will Eastern forests likely experience by 2100?
 - a. Hadley Hi (harsh scenario) temps vs. PCM Lo (mild scenario) temps, from any species page, link to “[Predictor Maps](#)” / “[Compare Predictors](#)”, then pull down for Left/Right image to Mean annual temperature, and pull down for Climate Scenario to PCM – B1 and HadleyCM3 – A1FI, and “[Update Maps](#)”. Then slider bar to compare. Or change Scenario to ‘Current’ to see possible changes.
 2. *What is the range of precipitation conditions the Eastern forests are likely to experience in 2100?
 - a. Same as above only set Left/Right images to precipitation.
 3. *What might be the impact of large-scale energy conservation (reduction of CO2) on temperatures by 2100?
 - a. Hadley Hi vs. Hadley Lo temperature (low emissions vs. high emissions). Same as above only Climate Scenario pull downs to Hadley B1 and Hadley A1FI.
 - b. PCM Hi vs. PCM Lo temperature. Same for PCM B1 and A1FI
 4. What other predictors may influence outcomes of tree species models?
 - a. Soil pH
 - b. Potential soil productivity
 - c. Coarse soil texture (N010)
 - d. Depth to bedrock (RockDep) Same as above, pull down for Left/Right images.
 5. Where can I learn about the definitions of these predictors?
 - a. Predictors help file, “[Help](#)” button under “[Predictor Maps](#)” tab.
- A. **Species Information – Current Status** (can trace through upper right search box panel). Note: if you know the FIA number of the species of interest (and you can get that from “spp #” in the main table, “[Search for Trees & Birds](#)” / “[List of Trees](#)” or equivalent for birds), you can just substitute that in the address, e.g., 12 in this balsam fir example below.
6. *I’m interested in balsam fir. What does it look like and what do the seeds look like?
 - a. Search for balsam fir, then “[About balsam fir](#)” / “[Photos of balsam fir in USDA Plants Database](#)”



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7. What else might be known about the silvics of this species?
 - a. Silvics manual, link from [“About balsam fir”](#) / [“Silvics Manual”](#)
8. *What is the current distribution of balsam fir?
 - a. In North America, link from [“Range and Niche Maps”](#) / [“IV with Range \(Entire Range\)”](#)
 - b. In eastern US, link from [“Range and Niche Maps”](#) / [“IV with Range \(Eastern USA & Canada\)”](#)
9. *What might be currently limiting the southern boundary of balsam fir?
 - a. Geographic predictors (growing season temperature >16.5C), link from [“Predictor Analysis”](#) / [“Geographic Predictor Maps”](#); look for division between not present (0.03 (class 1) importance on tmaysep >>16.5C) and present all other classes). = growing season temperature is a key limiter according to this analysis.
10. *What are primary variables driving balsam fir, according to the models?
 - a. Link to [“Predictor Analysis”](#) / [“Predictors Importance for balsam fir”](#); see ranked order of variables.
11. *What are some of the current limits for balsam fir in North America?
 - a. Niche maps (precipitation and temperature), link to [“Range and Niche Maps”](#) / [“US & Canada Climate”](#); see the range of temperature and precipitation for the current distribution. Can also do same for soil and elevation variables.
12. *How might I learn more about bur oak’s potential response to fire?
 - a. Search bur oak, link to [“About bur oak”](#) / [“Life History and Disturbance Response”](#) / [“Fire”](#).

B. Species information – Potential Changes with Climate Change

13. *What are some likely scenarios of change in habitat for black cherry (species 762) under climate change, and where might the species increase and decrease in habitat?
 - a. Six maps and difference maps, link to [“Summary of Predicted Changes”](#) / [“Summary Change Maps”](#)
 - b. Also easily evaluated with main frame, center tab [“Projected Future Habitat”](#) / [“Compare Scenarios”](#), and compare current modeled to future scenario with slider bar.
14. *How far and what direction might shortleaf pine habitat move by 2100?
 - a. Mean center maps, species 110. Link to [“Summary of Predicted Changes”](#) / [“Mean Center of Distribution”](#)
15. *So what kind of changes are we talking about – the numbers for shortleaf pine, an increaser?
 - a. Overall score of habitat suitability for each scenario is found in table linked as [“Projected Future Habitat”](#) / [“Compare Scenarios”](#) / [“Statistics”](#), and the ratio of Future: Current IV is above 1.5 under all scenarios.

C. Regional assessment of vulnerability (example, Central Appalachians)

16. What is the most abundant species in the Central Appalachian region?
 - a. Link to [“Regional Assessments”](#), scroll to [“Central Appalachians”](#), download pdf or excel file, and search the [“Current IV”](#) (either FIA or Current Modeled) for maximum numbered species.
17. What species are most inclined to decrease in habitat under the GFDL A1FI scenario?
 - a. Link as in #16 and get the excel table. Sort the column [“Change Class / GFDL A1FI”](#) and find the species with ‘Lg. Dec.’.
18. Of those Large Decreasers, which ones are most adaptable for a changing climate?
 - a. Link and get table as in #17. Sort again, with 1st sort on GFDL A1FI as above, and second on [‘Adapt’](#). Those with green Adapt scores are most adapted and should do better than the model might suggest.