Regional Impacts of Climate Change on Forests

Science Applications and Needs Workshop - Madison

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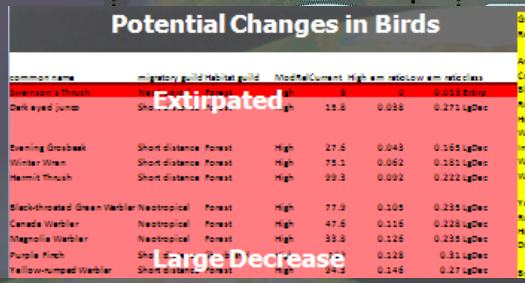
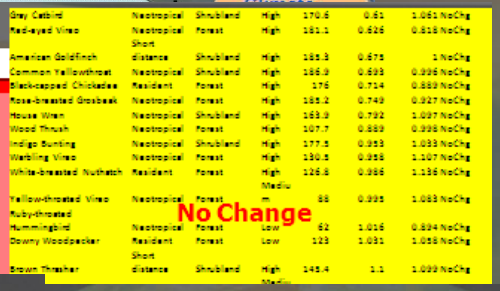
Stephen Matthews, Matthew Peters

Northern Research Station
NRS-02, Delaware, OH

Outline

- Overview of our approach to modeling
- Results from this vul t
- Key findings





Biological Effects in N Wisconsin

The above conditions will result in some fairly **dramatic biologic effects** :

- For 73 modeled tree species, most will have their suitable habitat shift north (LU)
- 21 species were modeled to increase habitat, 19 decrease, 6 no change, and 27 may have habitat move in from the south (HU)
- Some key dominant species, like sugar maple, balsam fir, paper birch, and aspen, are likely to decline in habitat (MU)
- Major associates of 11 of 12 forest types could see declines in habitat, with only the oak-hickory type increasing (HU)

Biological Effects (2)

- Some species, like red maple, have relatively greate biological capacity to deal with disturbance and oth changes, and will likely do much better than the mo predict (MU) converse
- Changes in species composition could happen quick disturbance) or, more likely, slowly, as trees live a l and there will long lag times (HU)
- There could also be niche gaps open up during tran which will invite non-native invasives along with na invaders (HU)

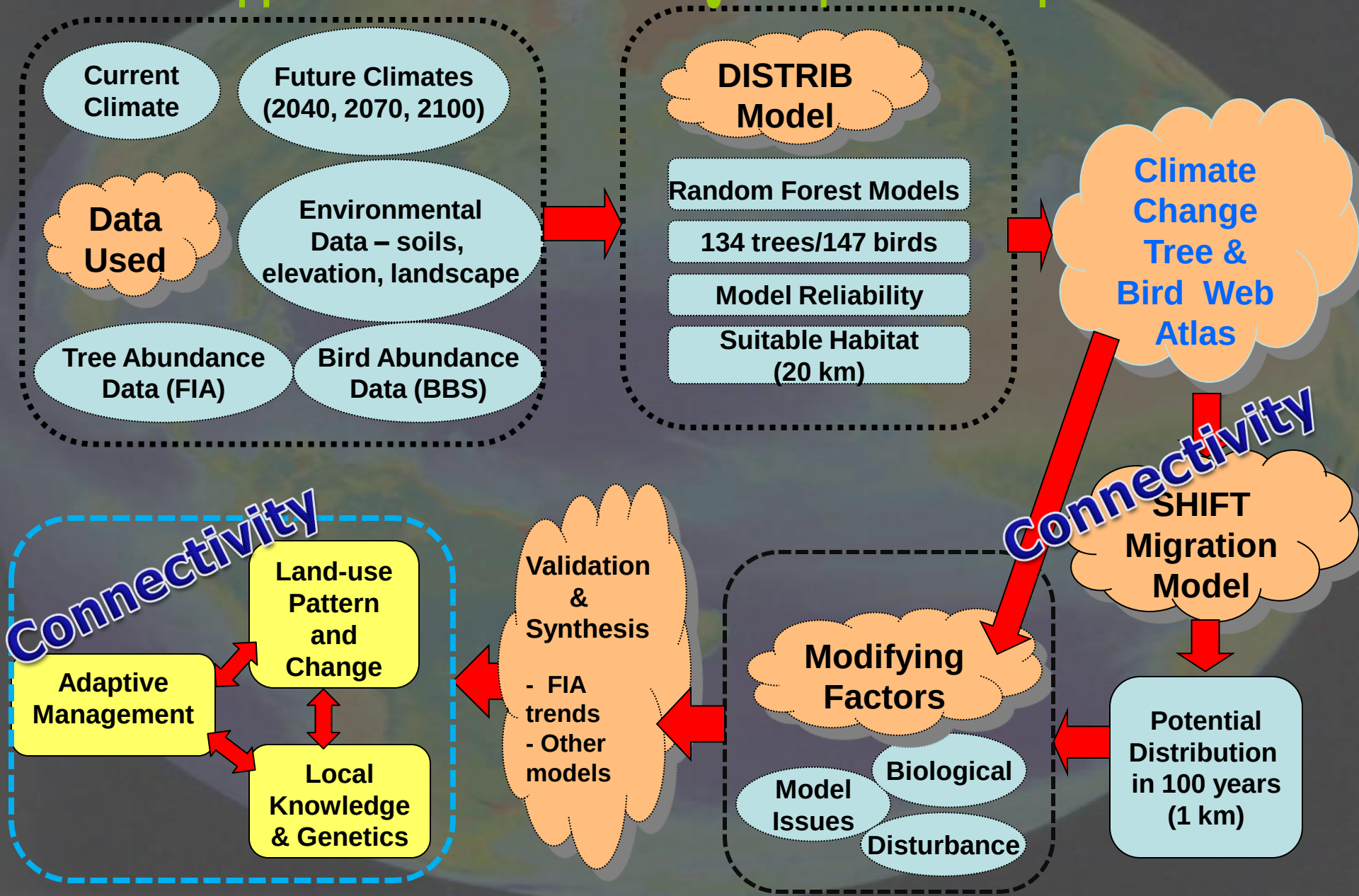
Biological Effects (3)

- Fragmented habitats slow the potential for unassisted migration of species (MU)
- Rare species are much more difficult to model, but som proportion of them will be more severely threatened wi climate change (LU)
- Of the 77 forest and shrubland birds currently or with potential future habitat in the region, 23 show large declines in habitat, 13 show large increases, and 14 species may have habitat move into the region.
- Many of the 'loser' species show associations with bore forest tree species (e.g. evening grosbeak and mournin warbler) that are projected to decline in the region.

Challenges of modeling species impacts of climate change

Bottom line: we need to incorporate different approaches to quantify and "whittle away" at uncertainties to develop ecologically informed projections – modeling is a key tool to do this

Our Approach: Climate Change Impacts on Species

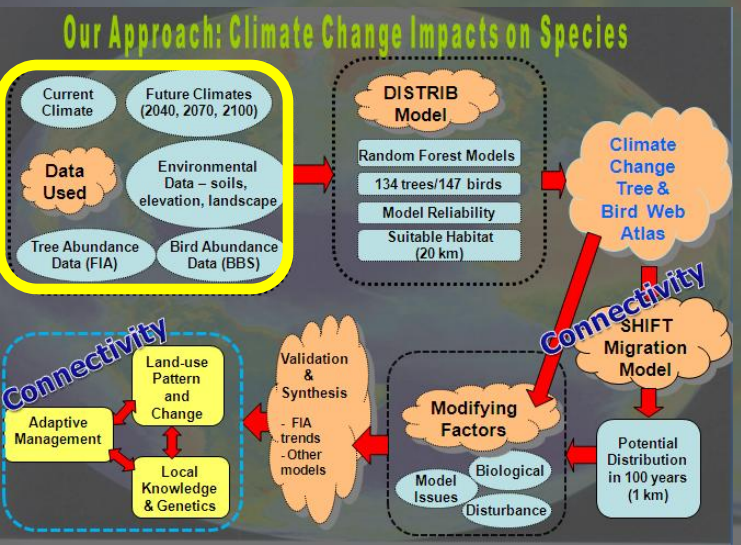


Assembling responses

Forest Inventory and Analysis (FIA)

- 37 states east of 100th meridian
- 134 tree taxa
- 103,488 plots
- 2,938,518 tree records

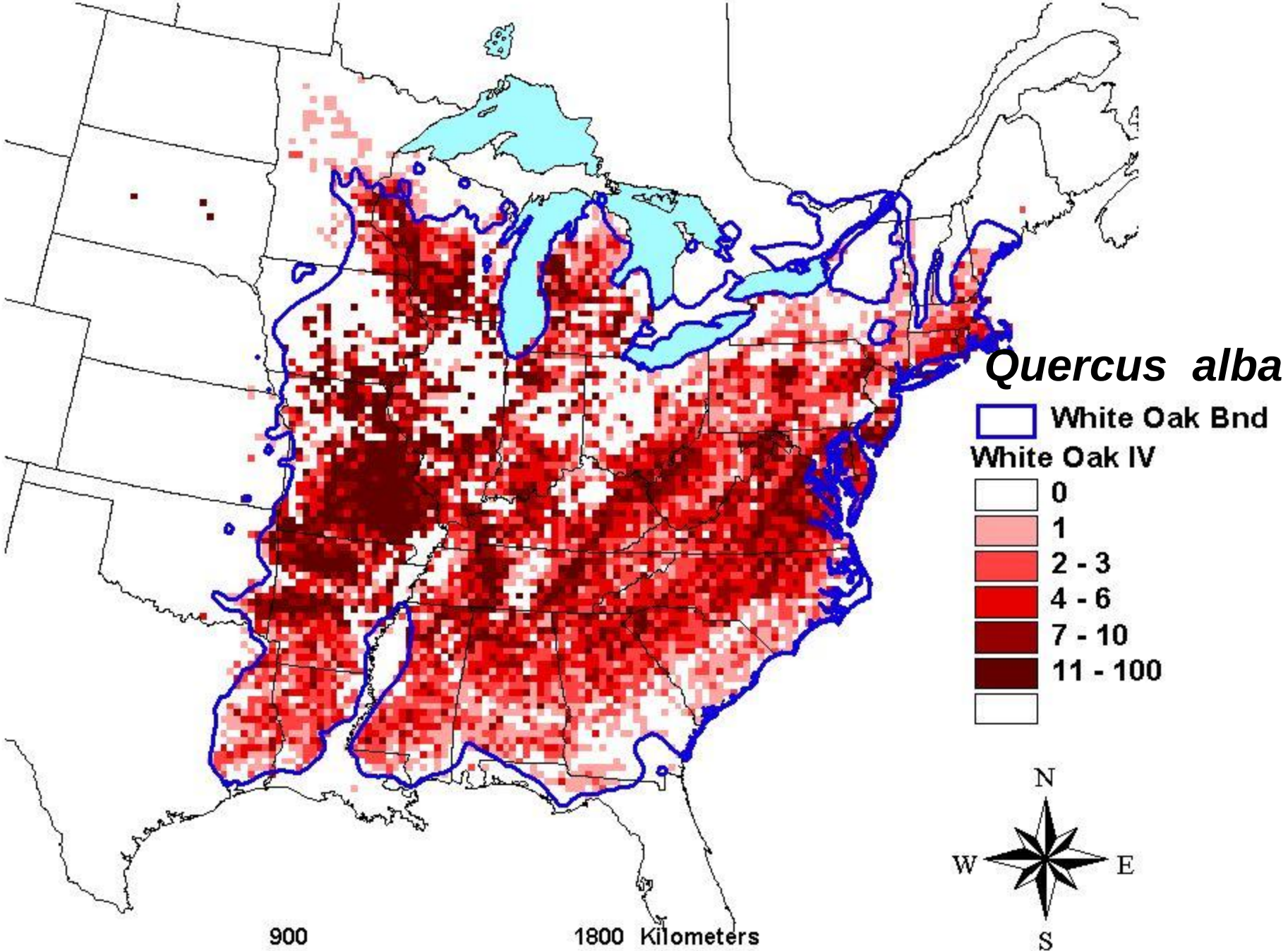
- Extract FIA plot data by State
- Calculate Importance Value (IV) for each species (basal area & no. of stems)
- Aggregate plots to 20x20 km grids (approx. 10,000 cells for eastern US)



OUTPUT

Importance Values (Abundances) (IV) for 134 tree species by 20 km cell (Range of IV: 0-100)

White Oak Importance Value and Little's Bnd



Tree species predictors

38 Predictors

- 7 Climate
- 9 Soil Classes
- 13 Soil Properties
- 5 Elevation
- 3 Land-use
- 1 Fragmentation Index

Current

GCMs, 2100

HadCM3
GFDL
PCM

IPCC Carbon Emission Scenarios

A1fi (High)
B1 (Low)

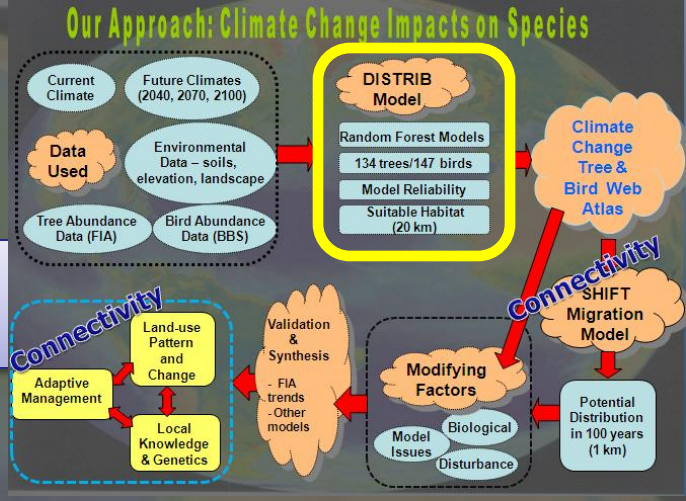
A1fi + HadCM3 (HadHi) – Most extreme

B1 + PCM (PCMLo)– Least extreme

Had+GFDL+PCM/A1fi – Ave Hi

Had+GFDL+PCM/B1 – Ave Lo

Modeling species habitats



(Importance Values)

FIA Current

Importance Values for 134 Tree Species

DISTRIB Tree Model

Model Predicted Current

Climate
- **Soil**
- **Elevation**
- **Land-use**
- **Landscape**

GCM Climate Swap

Model Predicted Future Suitable Habitat

HadCM3, PCM, GFDL
(Hi & Low Emissions)

Importance Maps

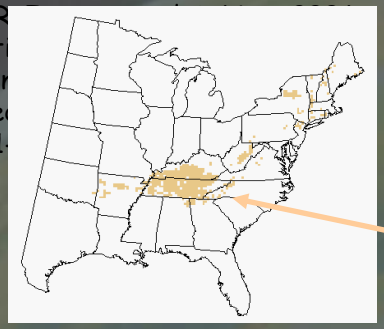
Hotspot Change Maps

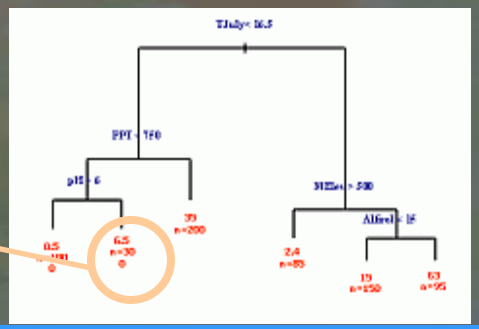
Mean Center Distribution Maps

Ranked Species Lists

Tri-Model Approach

Prasad, A. M., L. R
Newer classificati
techniques: baggi
for ecological pre
Ecosystems 9:181-



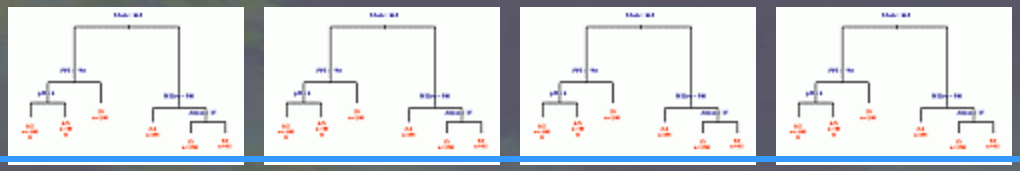


Helps understand relationships, and map drivers

TJuly < 16.5 &
PPT < 750 &
PH <= 6

Single Decision Tree

2/3 random sampling of observations for each tree



30 decision trees

Bagging Trees

use 30 decision trees to assess variability among individual tree models - a measure of model reliability

Random sampling + randomized subset of predictors for each tree

1000 decision trees

Random Forests

best for prediction without overfitting

Important!

- With these DISTRIB models, we are predicting potential suitable habitat by year 2100. We are NOT predicting where the species will be at that time, as great lag times are involved in tree species migrations.
- We attempt to get at the potential movements over the next 100 yrs with the SHIFT model.

Climate Change Tree Atlas

USDA United States Department of Agriculture Forest Service | Climate Change Tree Atlas | Northern Research Station

You are here: NRS Home / Tools & Applications / Climate Change Atlas / Tree Atlas

Climate Change Tree Atlas (A Spatial Database of 134 Tree Species of the Eastern USA)

Anantha M Prasad, Louis R Iverson, Steve Matthews, Matt Peters
NRS-4151, USDA Forest Service, Northern Research Station, Delaware, Ohio

Atlas Background | What's New | Citations | Credits | Atlas Help | Other Links (DropDownMenu)

Table of 134 Tree Species:

(Click Table-Header-Link to Sort by that Column - Ascending/Descending)

Model Reliability: High Medium Low

Reliability	Spp. #	Common Name	Scientific Name
	951	American basswood	*Tilia americana*
	531	American beech	*Fagus grandifolia*
	421	American chestnut	*Castanea dentata*
	972	American elm	*Ulmus americana*
	591	American holly	*Ilex opaca*
	391	American hornbeam:musclewood	*Carpinus caroliniana*
	935	American mountain-ash	*Sorbus americana*
	43	Atlantic white-cedar	*Chamaecyparis thyoides*

134 Species Combined/Compared

Combined Species Outputs

Summary of Predictors

Climate Change Tree Atlas | Northern Research Station

as Background | Acronyms | Caution! | Help | Other Links (DropDownMenu)

gar maple page

le (Acer saccharum) Pick Another Species

Species Information

Family: Aceraceae
Guild: persistent, slow-growing understory tolerant
Functional Lifeform: large deciduous tree

Life History and Disturbance Response

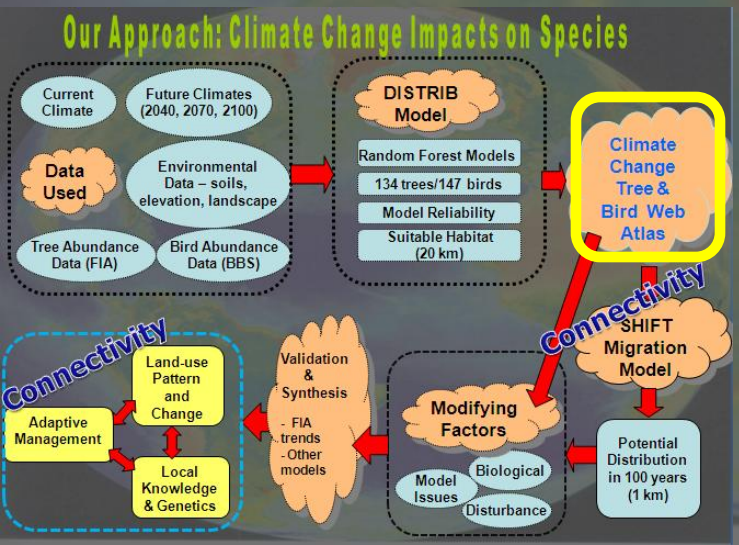
External Species Links

Silvics Manual: Click here for sugar maple
Plant Photos: Photos of the tree in USDA Plants Database
Google Earth: View current and modelled sugar maple

Research Products (IMPORTANT: Read this first)

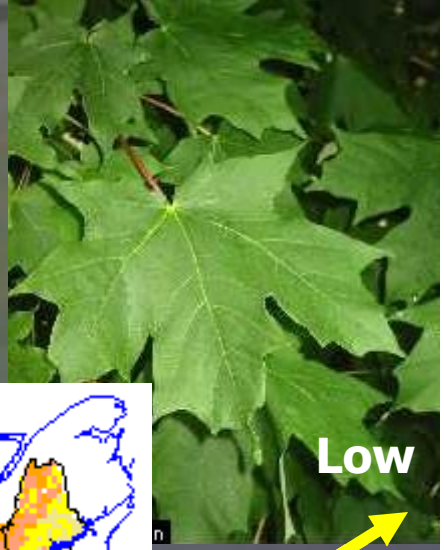
Current Distribution
- Abundance & Little's Range Maps
- HotSpot Maps
- Niche Maps
- Geographic Predictors Map
- Statistics, Tables & Interpretations

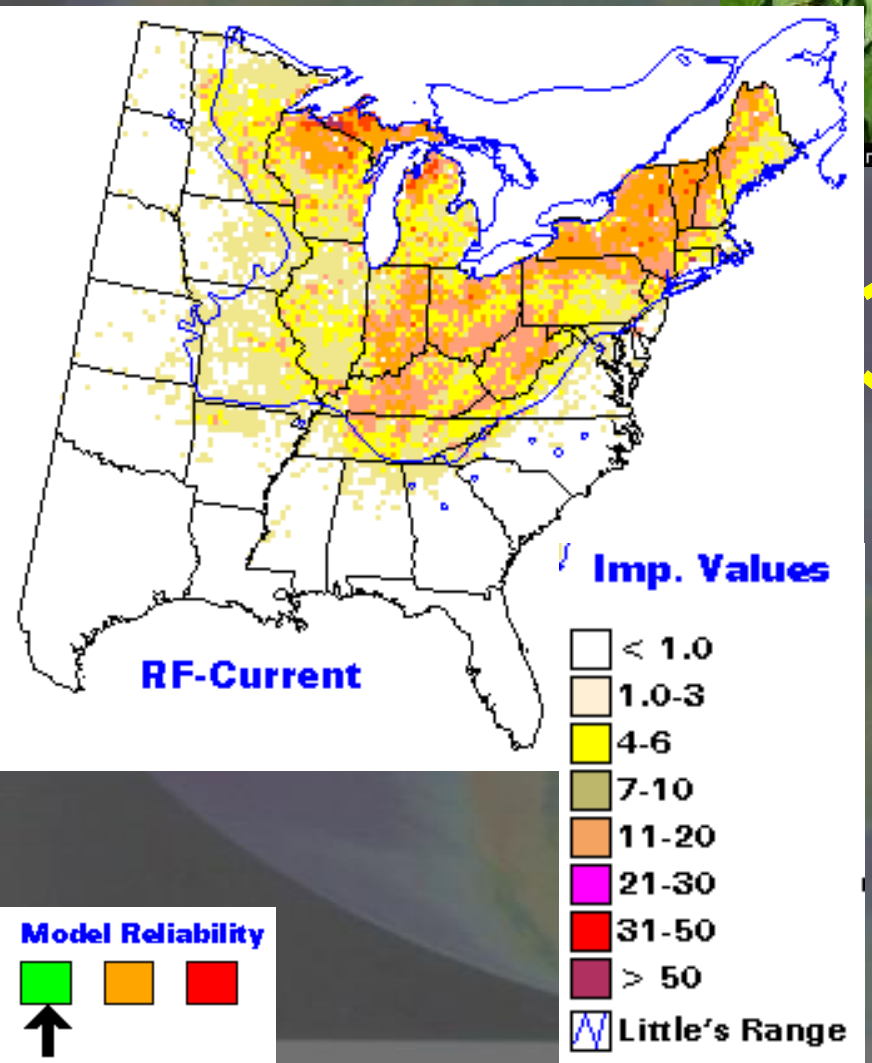
Modelled Future Habitat
- Abundance Change Maps
- Summary Change Maps
- HotSpot Change Maps
- Mean Center/Distribution Ellipse Maps
- Statistics, Tables & Interpretations



http://www.nrs.fs.fed.us/atlas

Sugar Maple

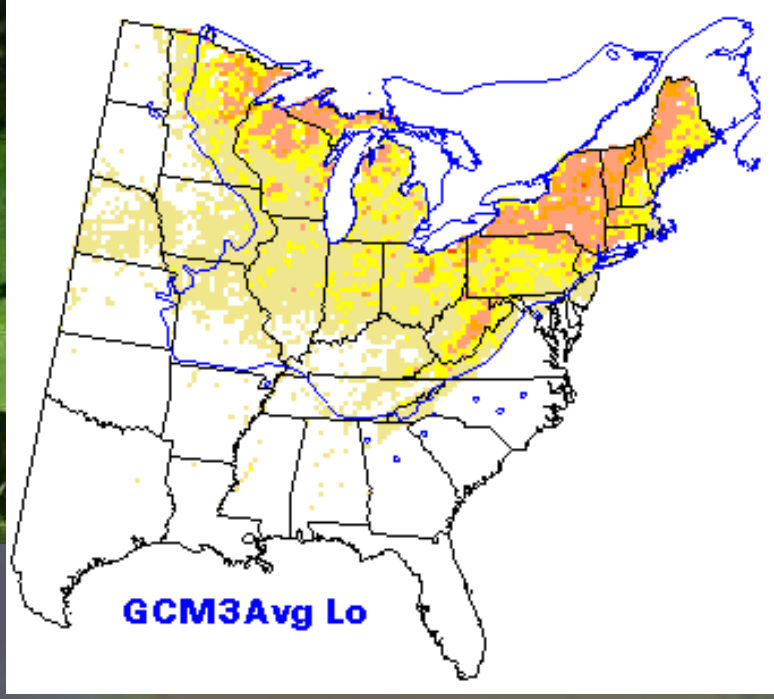


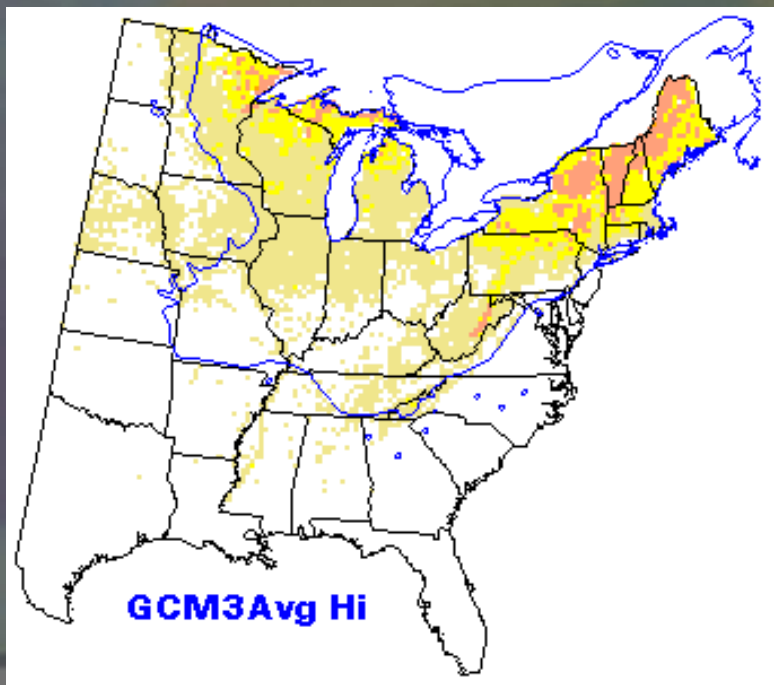


Low

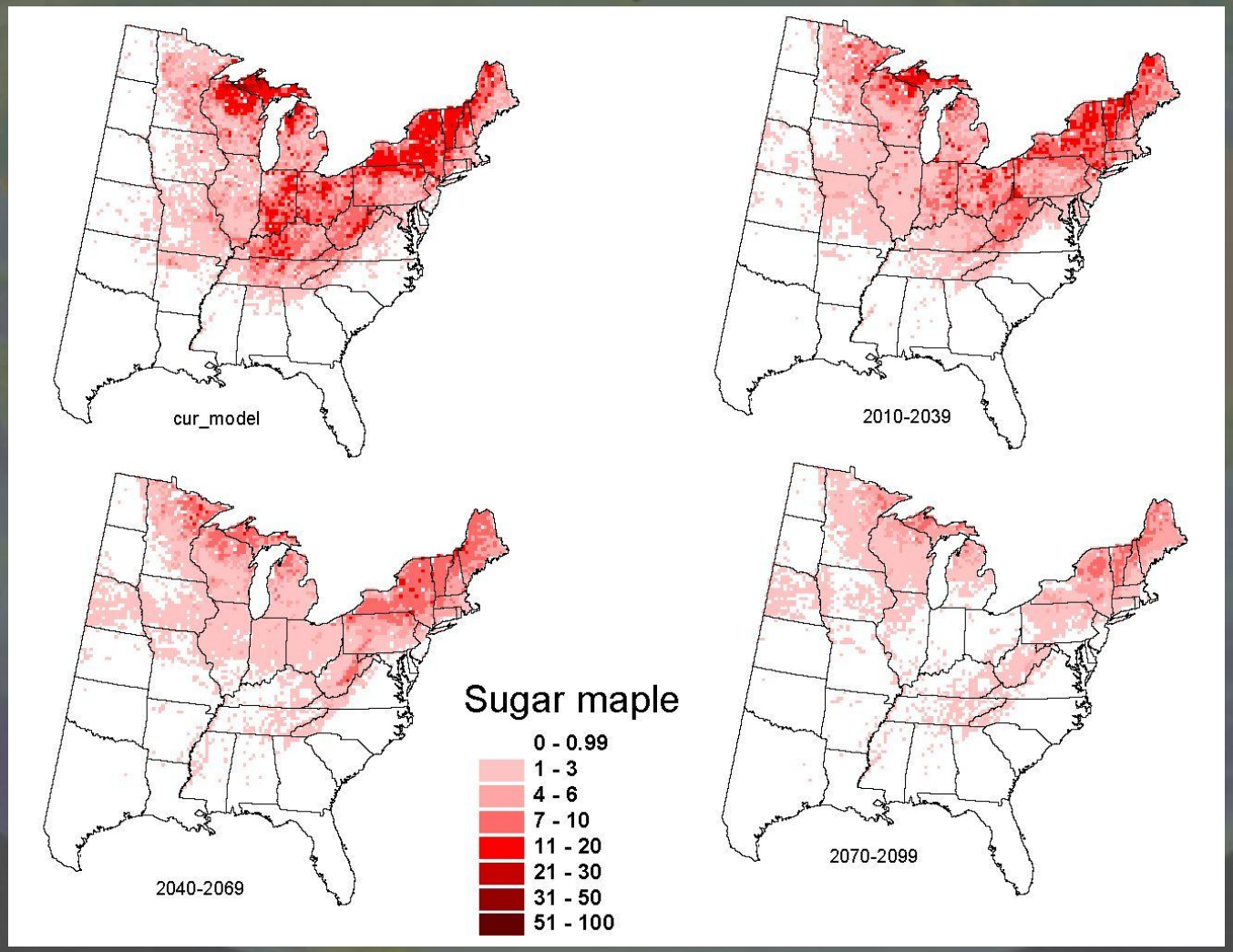
?

High



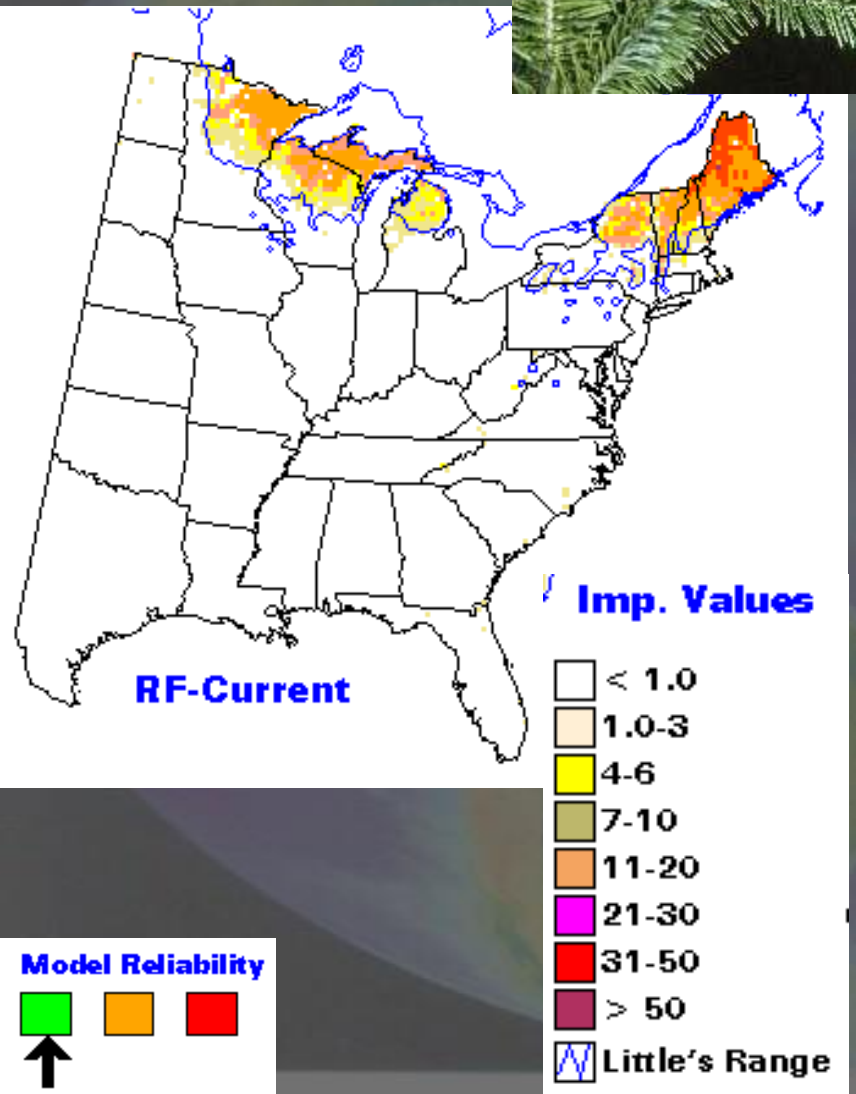


Sugar Maple – 1990, 2039, 2069, 2099



HadHi

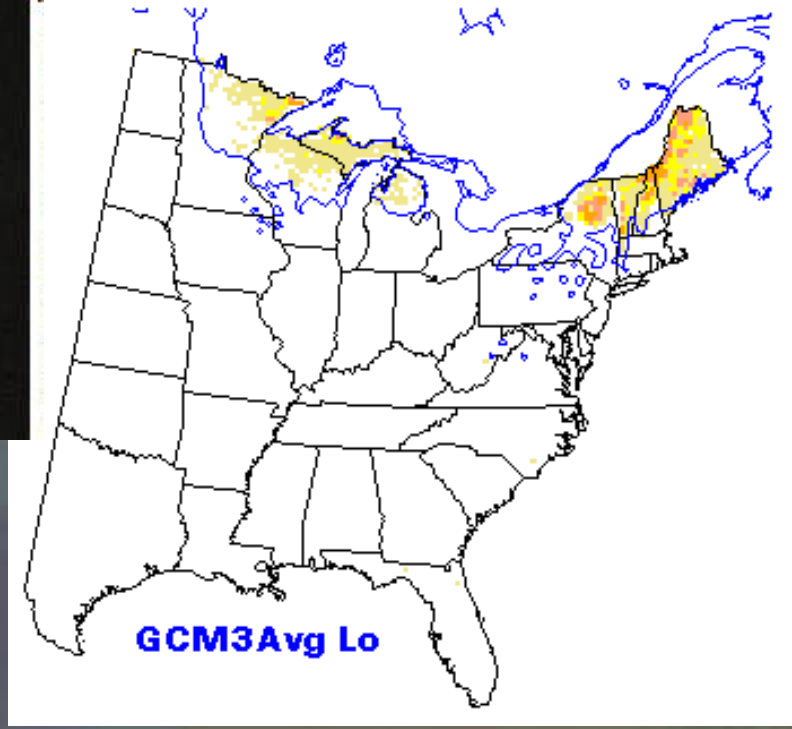
Balsam Fir

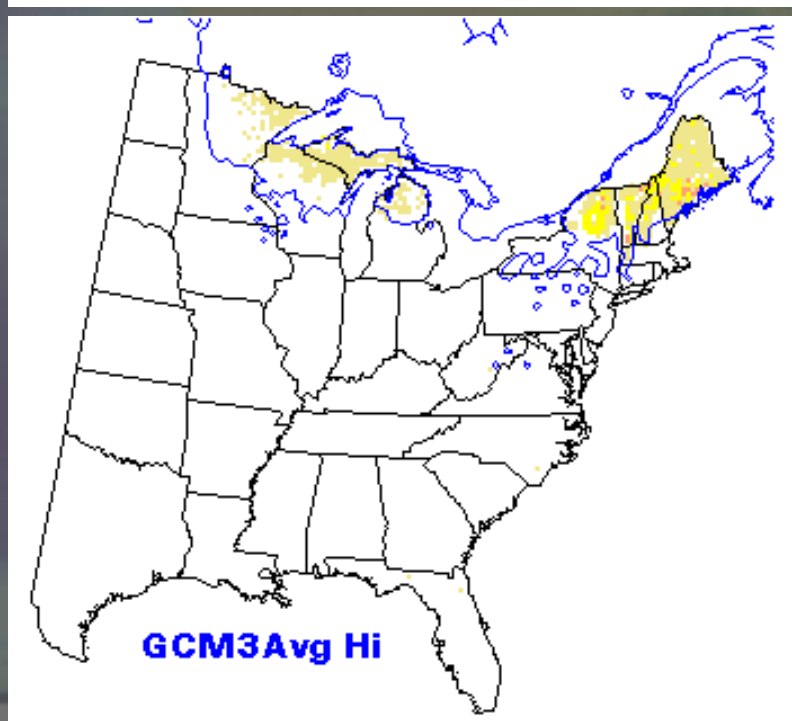


Low

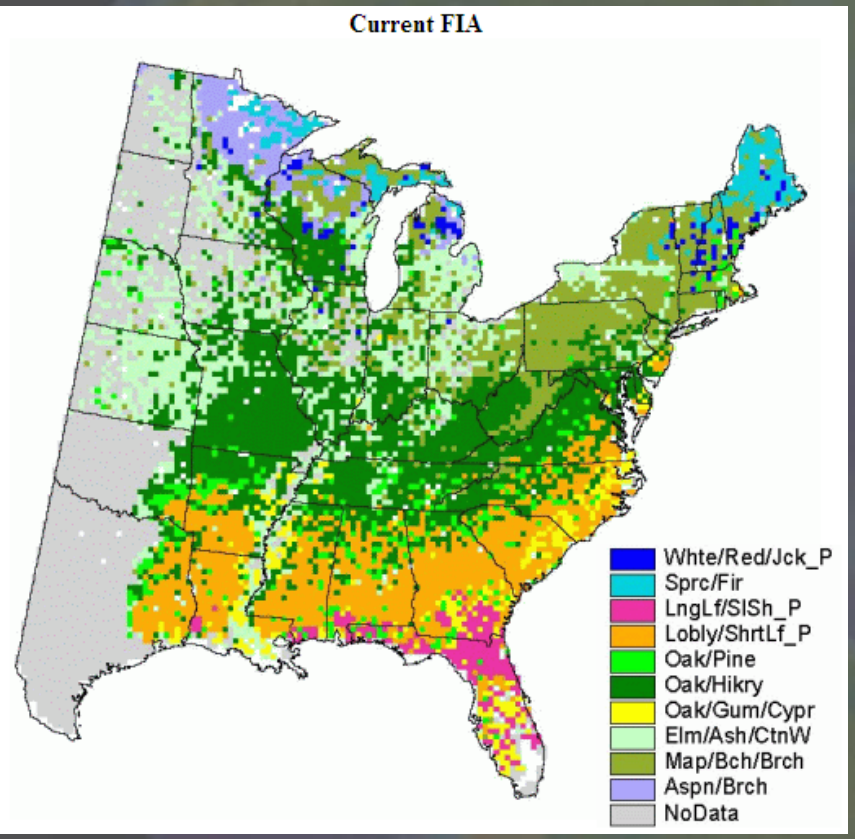
?

High





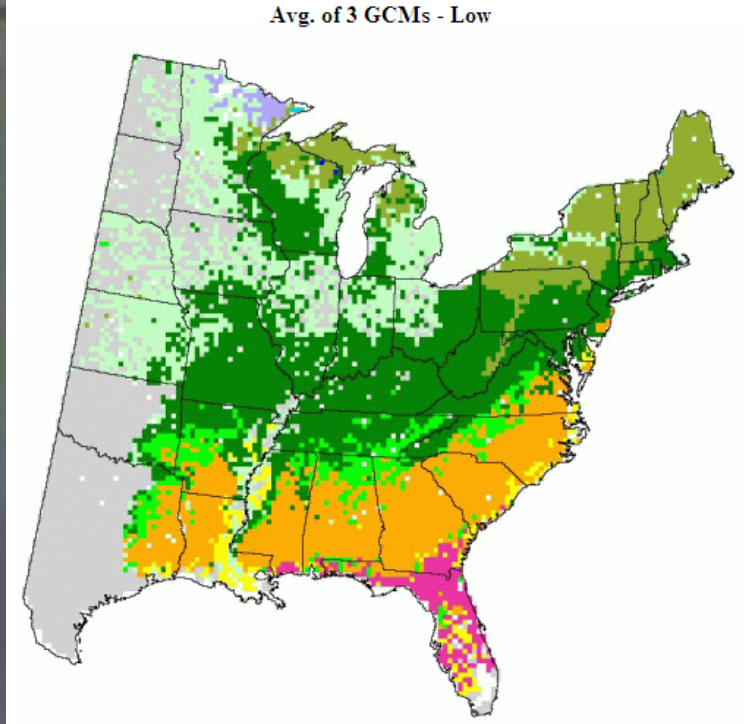
Forest Types

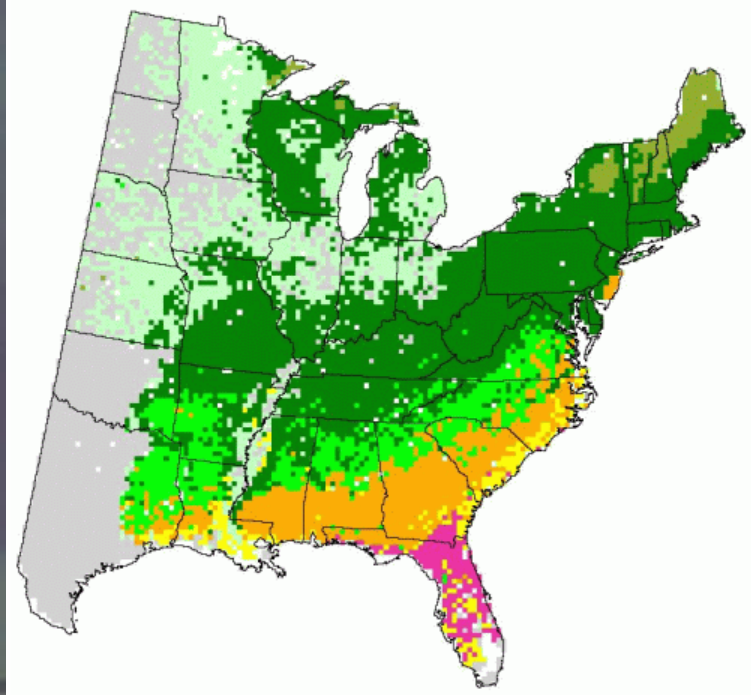


Low

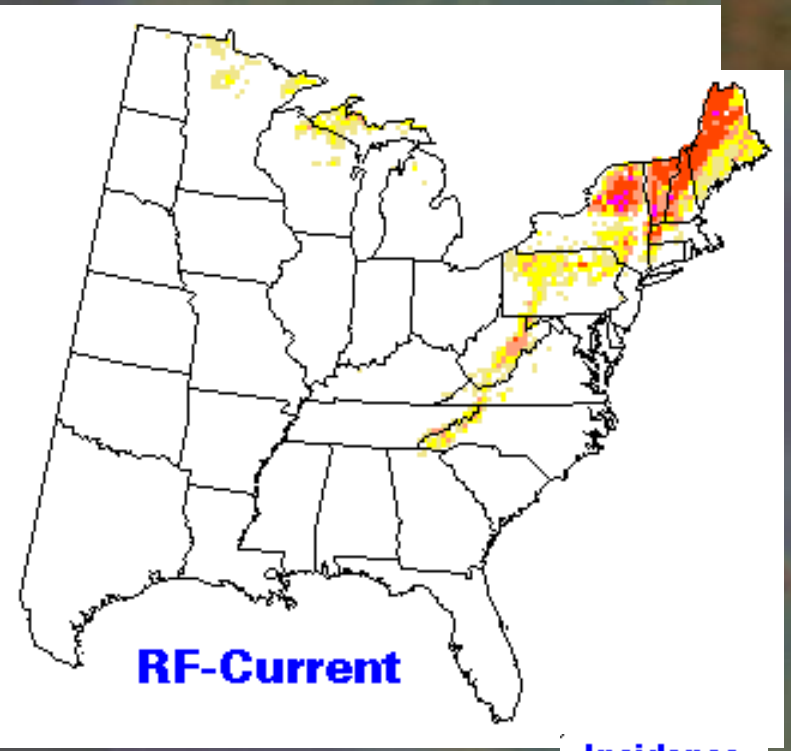
?

High





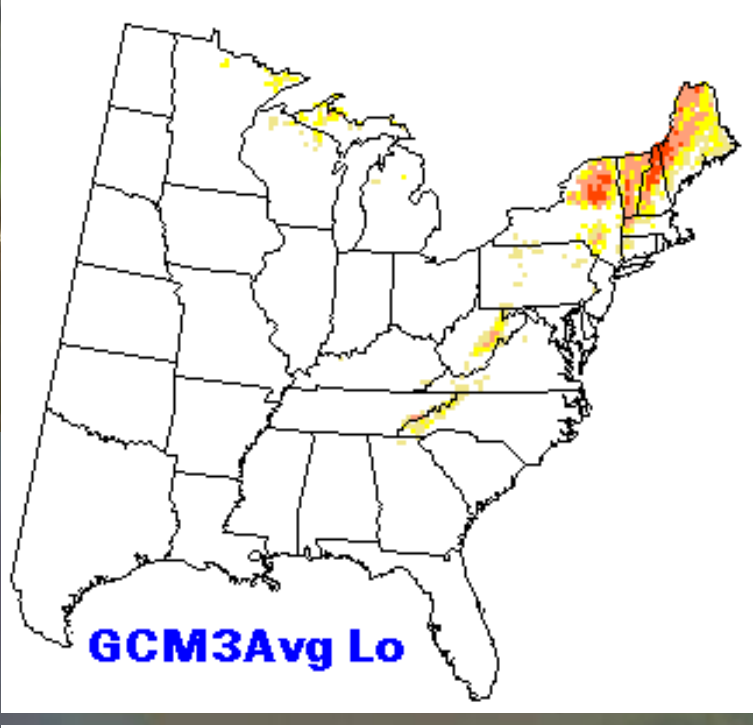
Black-Throated Blue Warbler

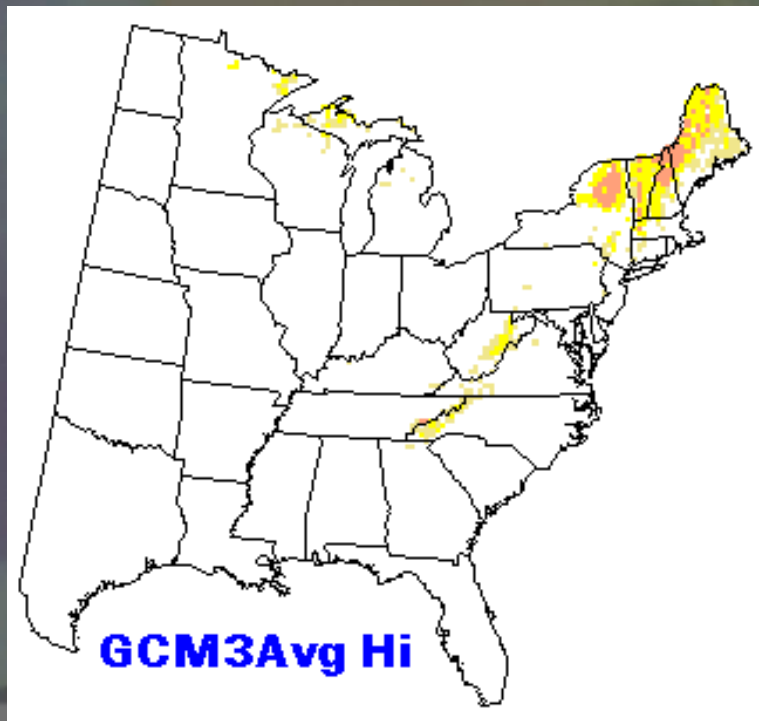


Low

?

High

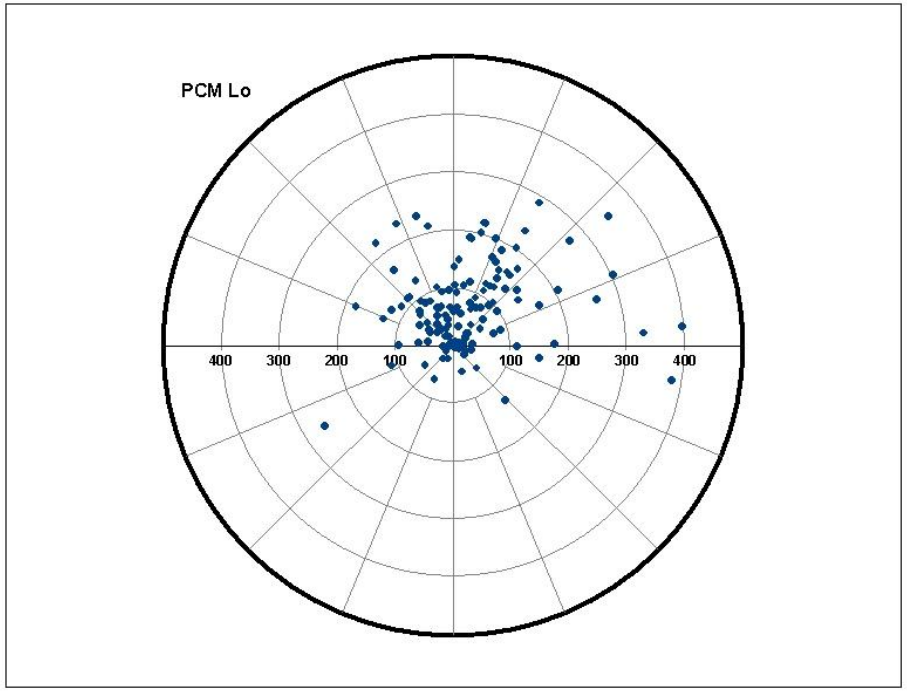




Incidence

- < 0.05
- 0.05-0.2
- 0.2-0.4
- 0.4-0.6
- 0.6-0.8
- 0.8-1.0

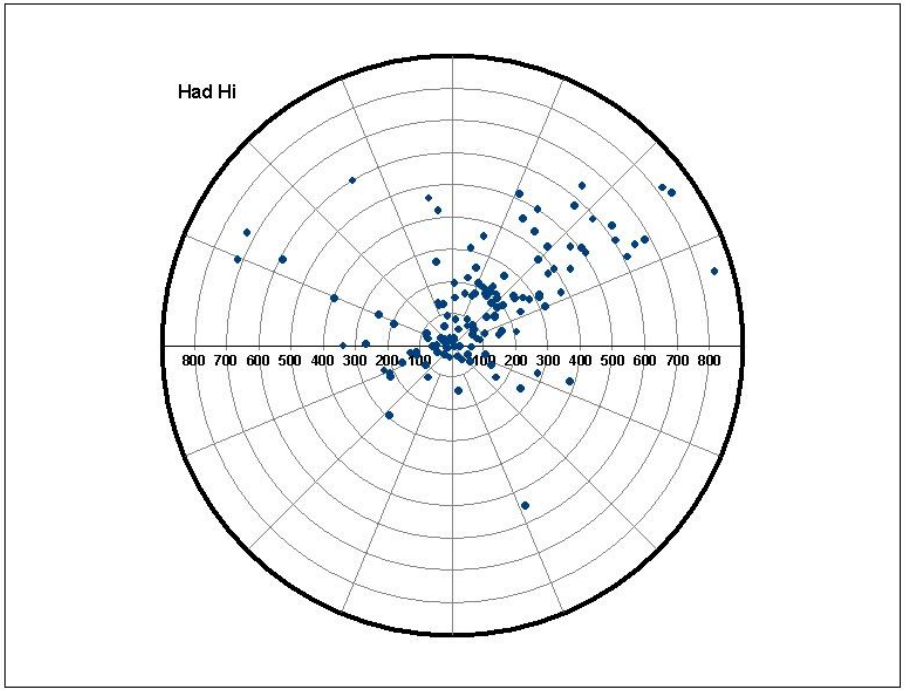
Mean Center Potential Movement



Two points:

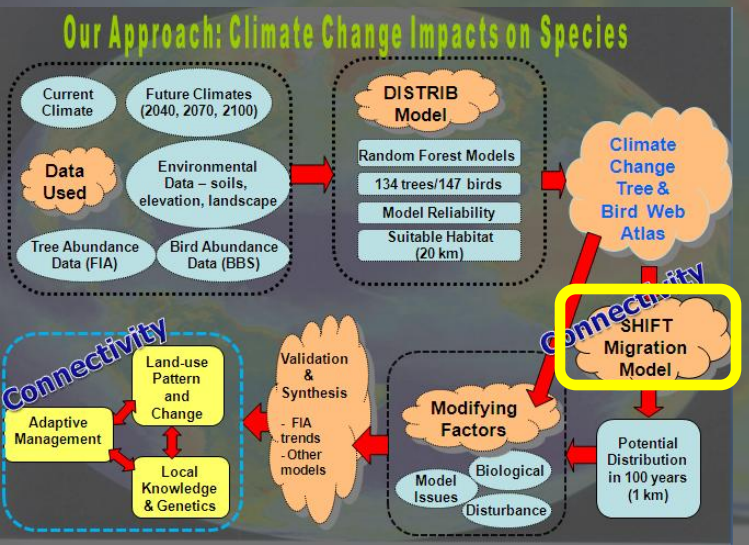
1. **Emission levels make big difference**
2. **Species will change individually**

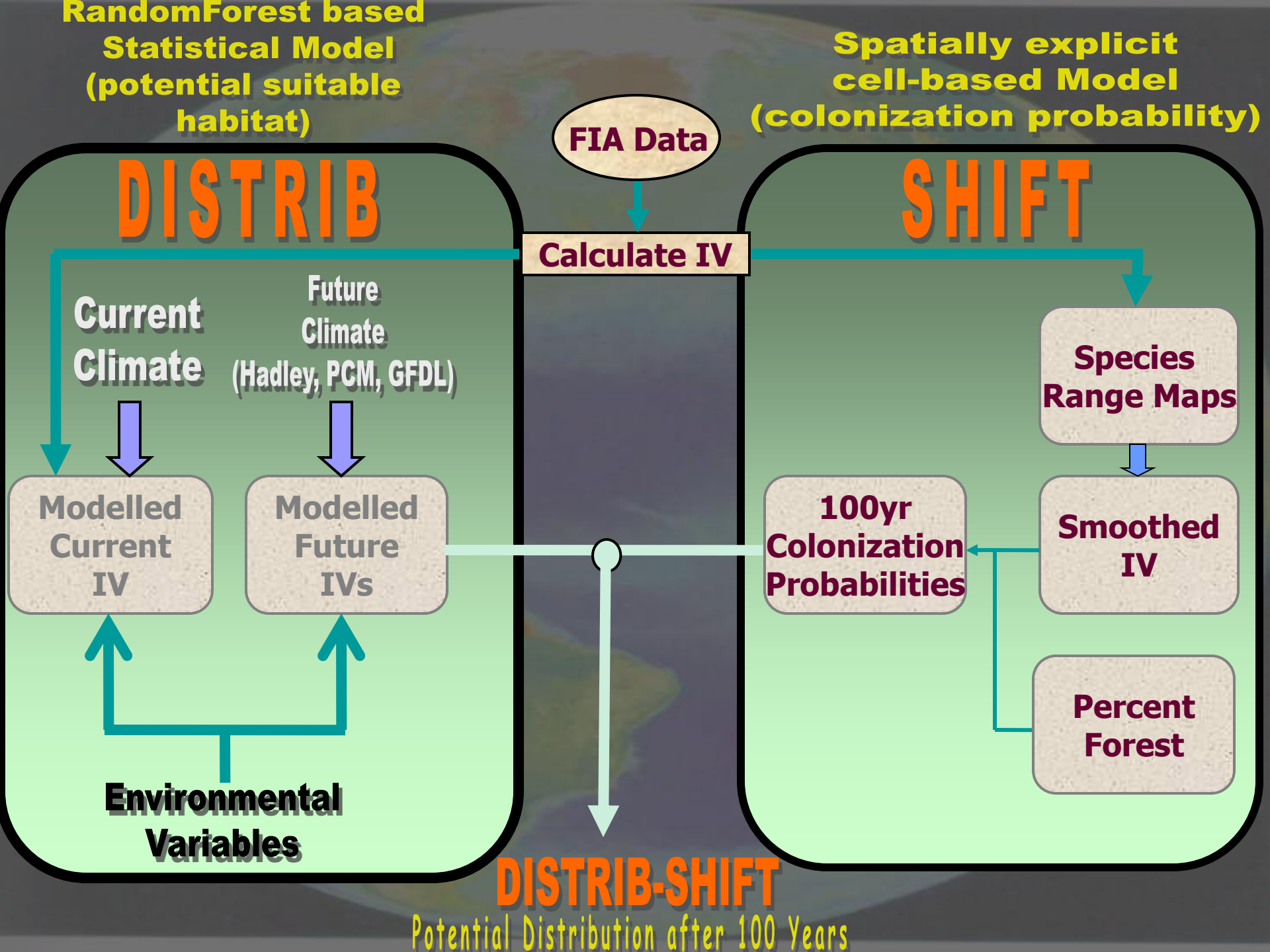
Direction and distance (km) movement



Lessons Learned

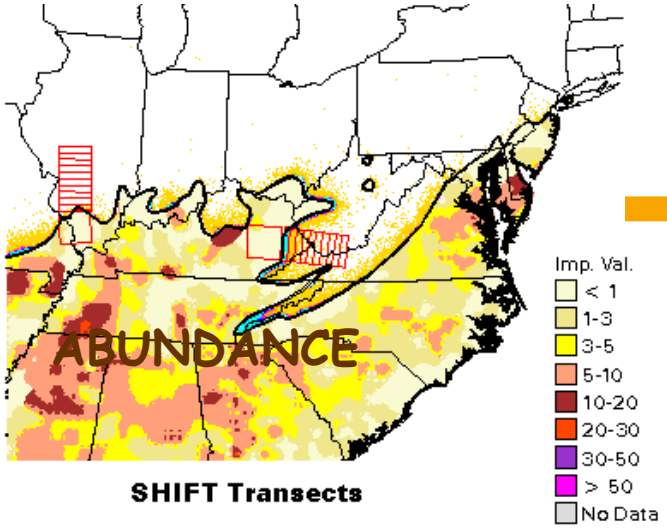
Separate the discussion of potential changes in suitable habitat from that of potential species range changes within a certain time frame.



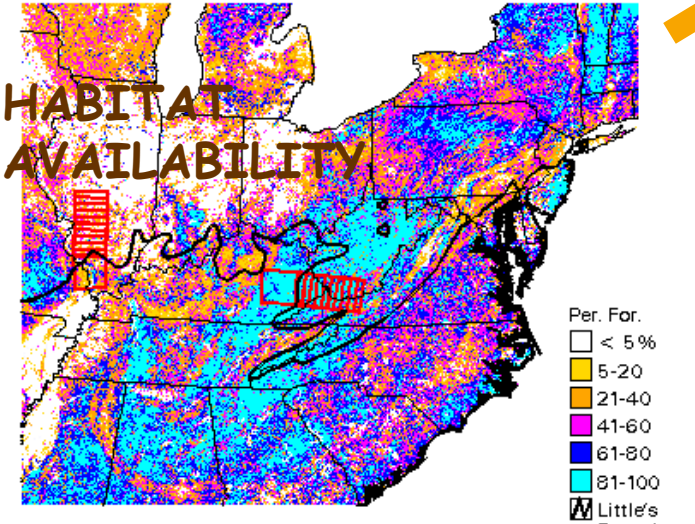

RandomForest based Statistical Model (potential suitable habitat)
Spatially explicit cell-based Model (colonization probability)
FIA Data
DISTRIB
SHIFT
Calculate IV
Current Climate
Future Climate (Hadley, PCM, GFDL)
Species Range Maps
Modelled Current IV
Modelled Future IVs
100yr Colonization Probabilities
Smoothed IV
Percent Forest
Environmental Variables
DISTRIB-SHIFT
Potential Distribution after 100 Years

How much of the new suitable habitat might get colonized in 100 years?

Quercus falcata var. falcata

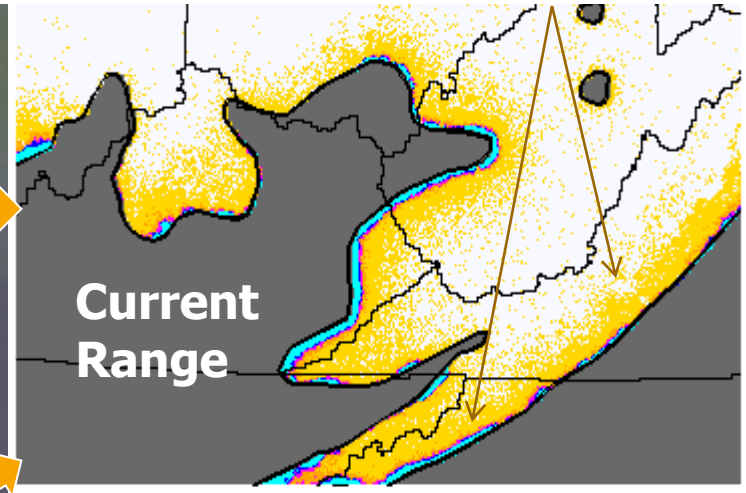


SHIFT Transcects



Forest Density Transcects

Probability of colonization, 0-100%, 100 yrs



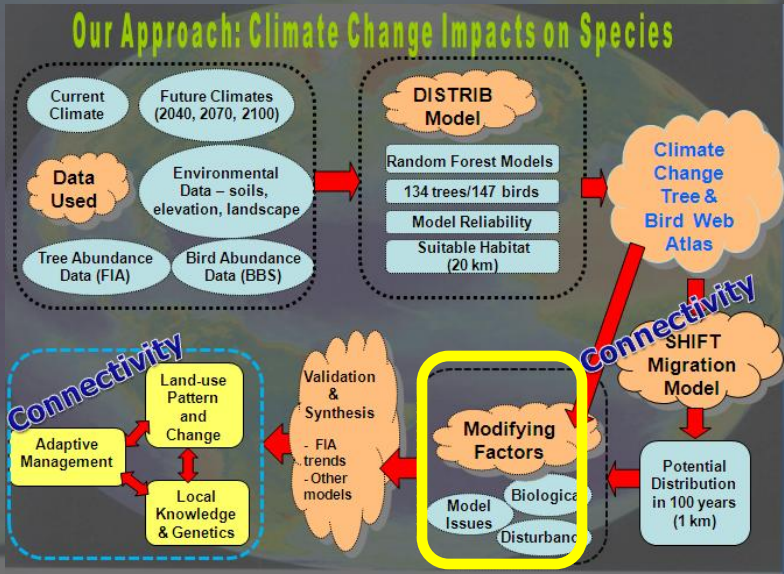
Zoomed SHIFT

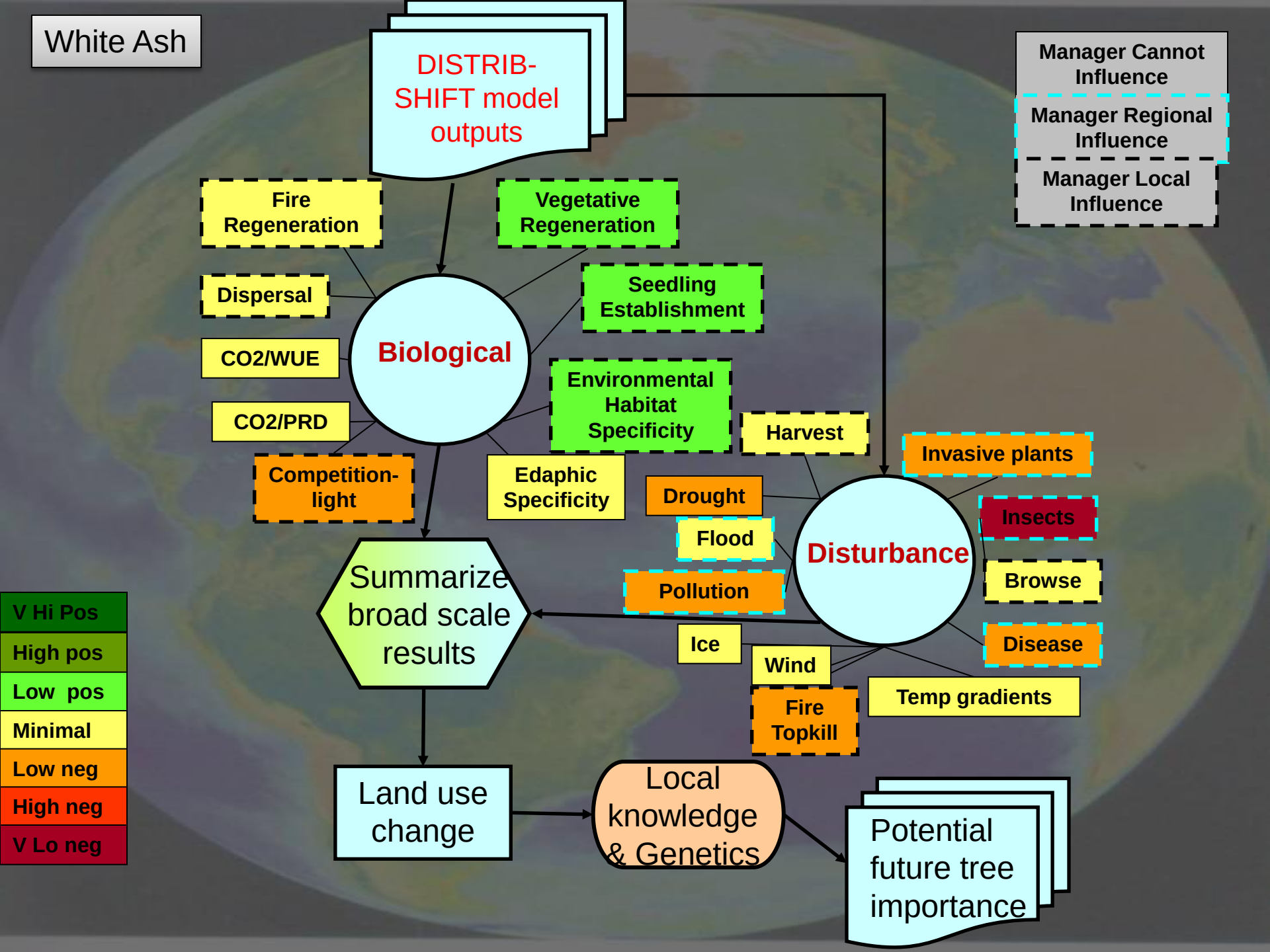
- For 5 species, less than 15% of new habitat would have much chance of getting colonized
- Large lag effect – suitable habitat changes much faster than species can migrate

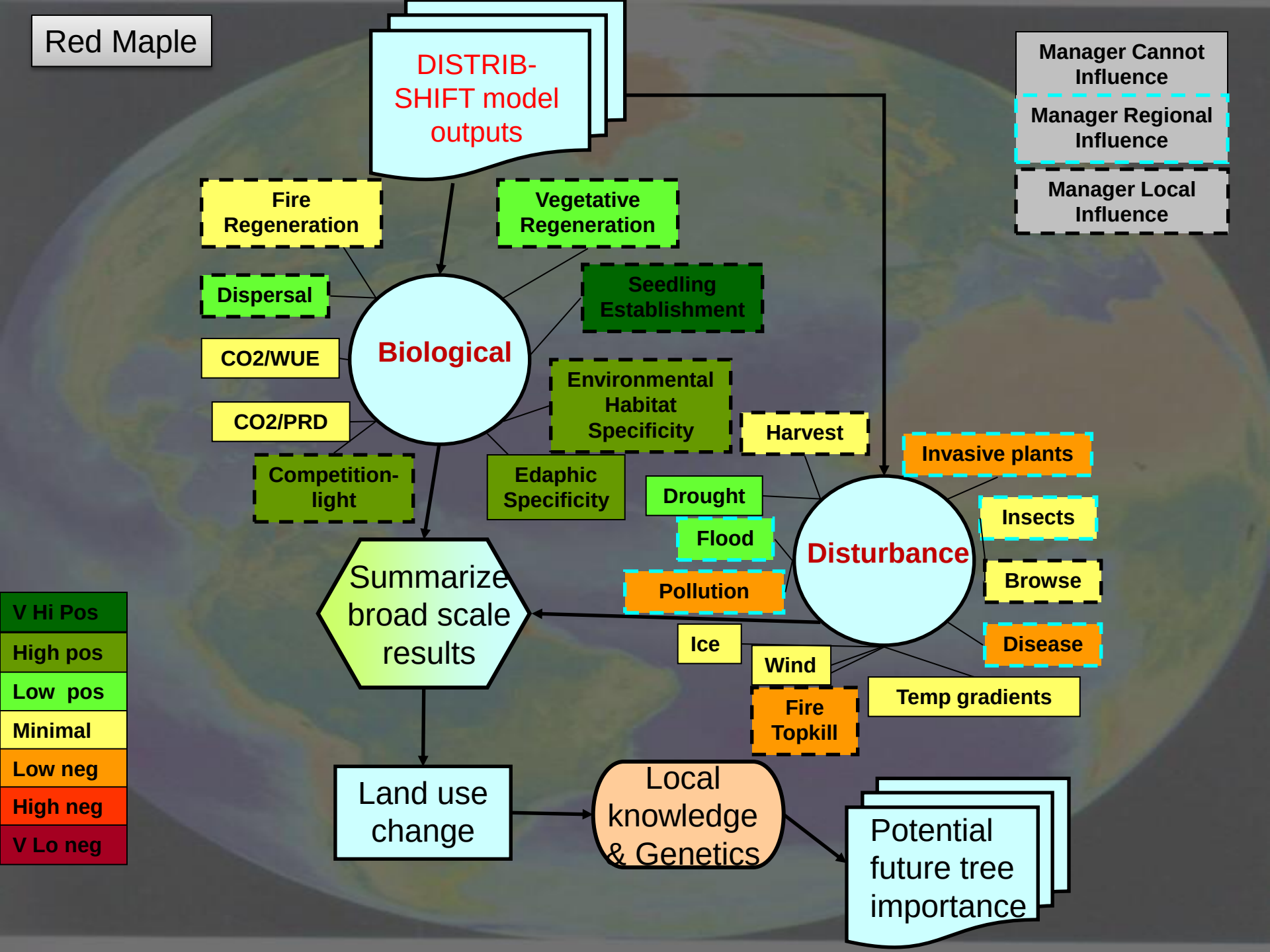
Lessons Learned

Consider variations in disturbance, biology, and model issues on each modeled species.

- No model, statistical or otherwise, can include all the biological or disturbance factors that may influence a species' response to climate change
- Need a method to incorporate other influences – modifying factors
- Glean literature and generate a scoring system to rate 21 factors




White Ash
DISTRIB-SHIFT model outputs
Manager Cannot Influence
Manager Regional Influence
Manager Local Influence
Fire Regeneration
Vegetative Regeneration
Dispersal
Seedling Establishment
CO2/WUE
Biological
Environmental Habitat Specificity
CO2/PRD
Harvest
Invasive plants
Competition-light
Edaphic Specificity
Drought
Insects
Flood
Disturbance
Pollution
Browse
Summarize broad scale results
Ice
Disease
Wind
Temp gradients
Fire Topkill
V Hi Pos
High pos
Low pos
Minimal
Low neg
High neg
V Lo neg
Land use change
Local knowledge & Genetics
Potential future tree importance


Red Maple
DISTRIB-SHIFT model outputs
Manager Cannot Influence
Manager Regional Influence
Manager Local Influence
Fire Regeneration
Vegetative Regeneration
Dispersal
Seedling Establishment
CO2/WUE
Biological
Environmental Habitat Specificity
CO2/PRD
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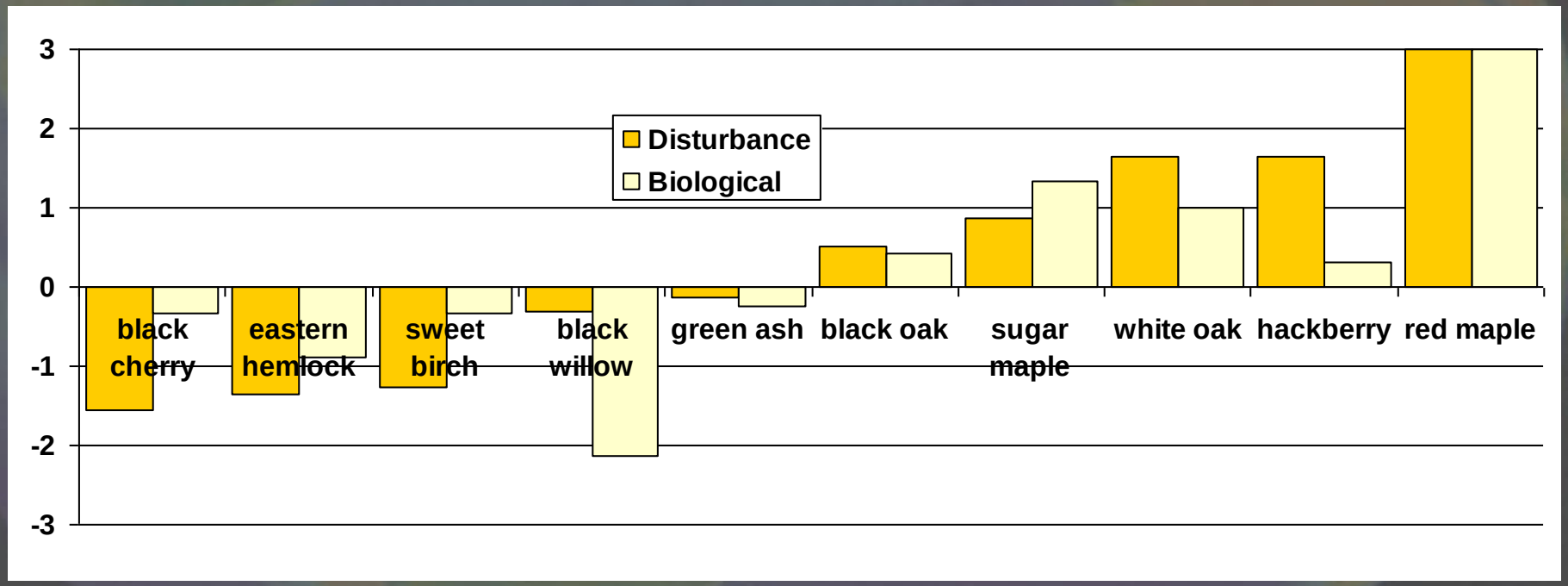
Ice
Disease
Wind
Temp gradients
Fire Topkill
V Hi Pos
High pos
Low pos
Minimal
Low neg
High neg
V Lo neg
Land use change
Local knowledge & Genetics
Potential future tree importance

Modifying Factor Scores

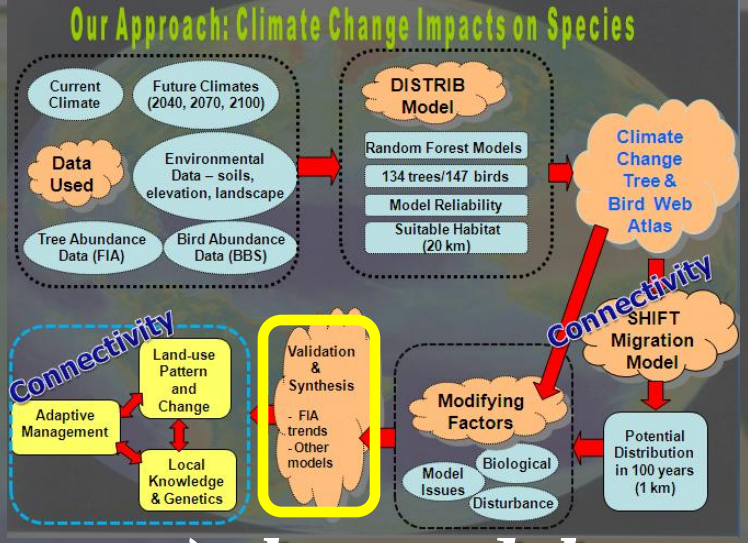
For selected species
Median = 0, scaled -3 to +3



Species may do worse than modeled **Species may do better than modele**

Depends also on species mix

Lessons Learned



Search for data to support (or not) the models

- Convergence of multiple models
  - e.g., Nielson et al. (MAPPS, MC1)
  - Mladenoff et al. (LANDIS-II)
- Documentations of species changes
  - e.g., northward or elevation expansions,
  - changes in forest types
- Other surrogate ways to determine possible trends
  - E.g., Woodall et al. (FIA data)

Forest Ecology and Management 257 (2009) 1434–1444

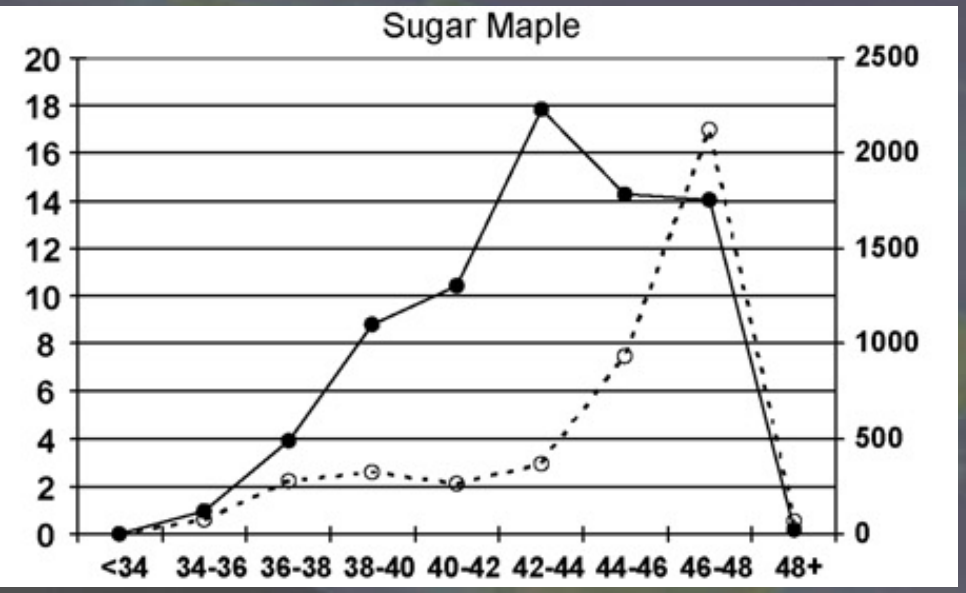
Contents lists available at ScienceDirect

Forest Ecology and Management

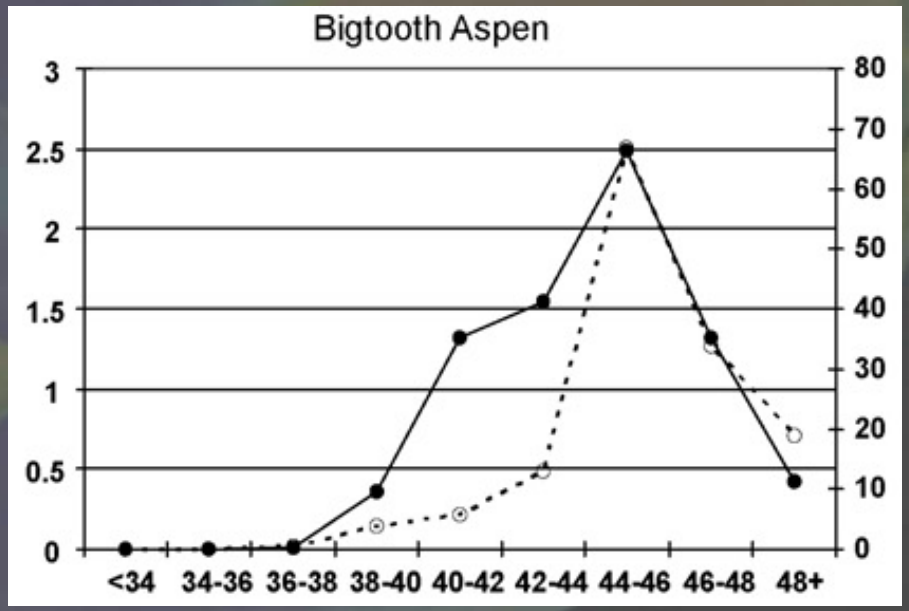
journal homepage: www.elsevier.com/locate/foreco

An indicator of tree migration in forests of the eastern United States

C.W. Woodall[a,*], C.M. Oswalt[b], J.A. Westfall[c], C.H. Perry[a], M.D. Nelson[a], A.O. Finley[d]



.13° North***

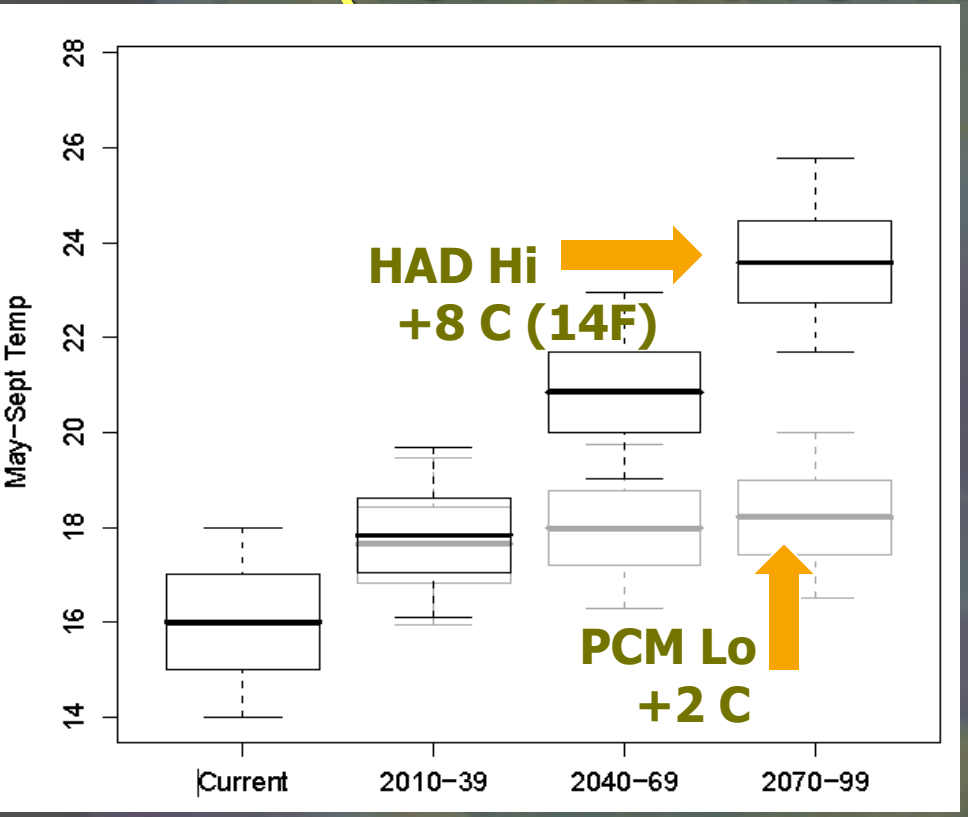


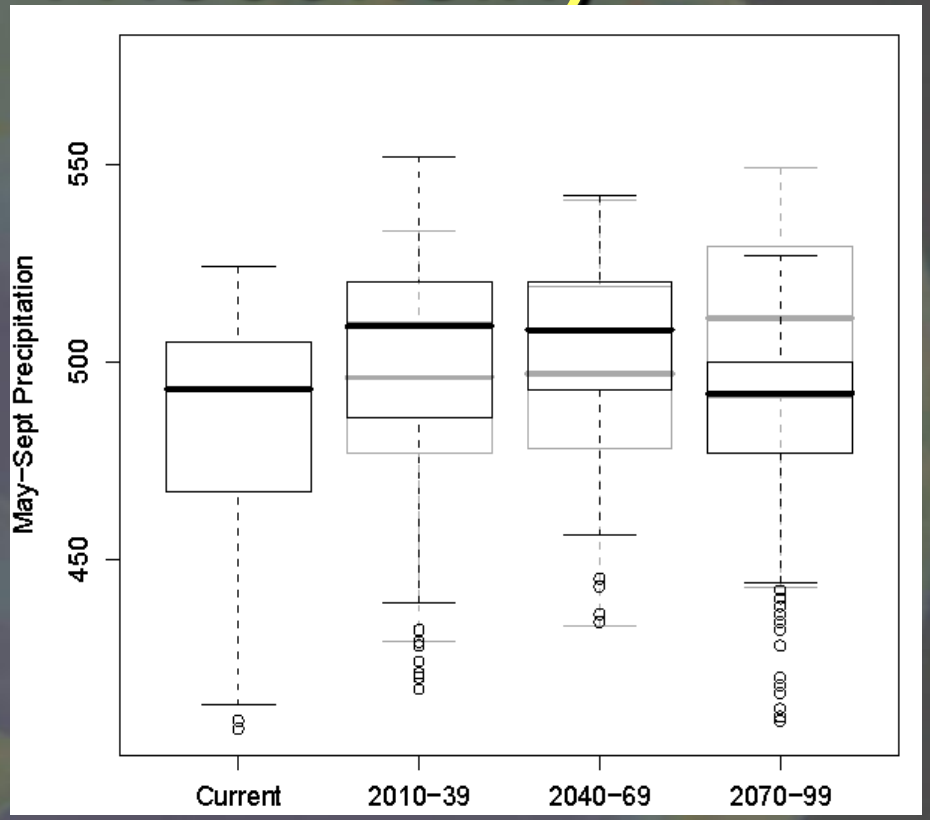
.46° North ***

37 of 40 species have general tendencies in agreement with our models

The “Model Forest” Project

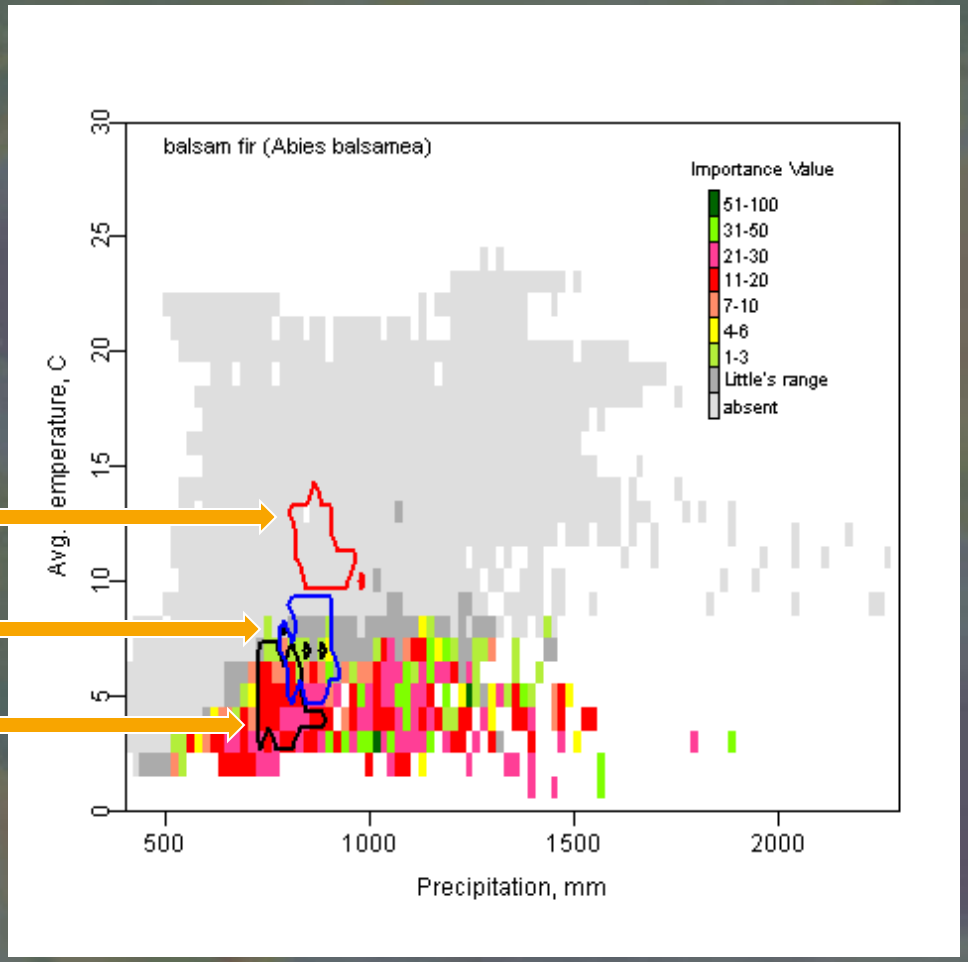
Expected growing season changes (for northern Wisconsin)





Growing season temperature higher and not much change in precipitation = more physiological stress on biota

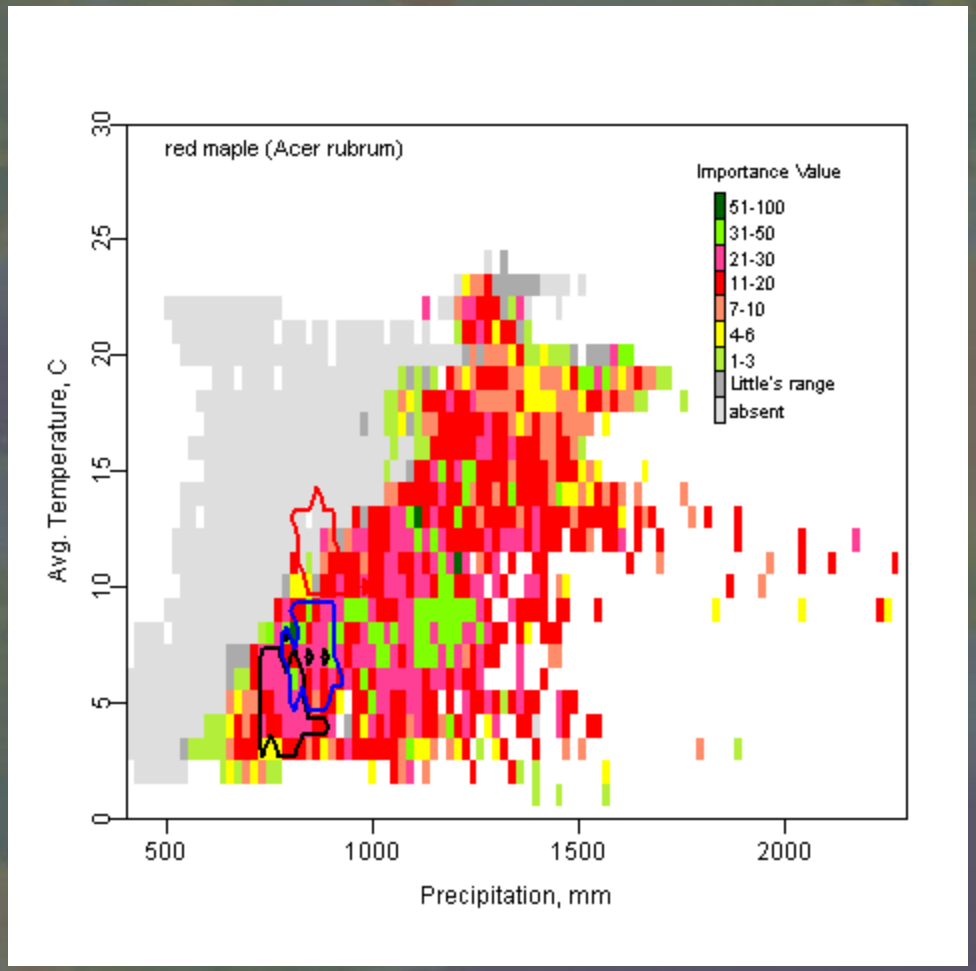
“Pac-man” diagrams

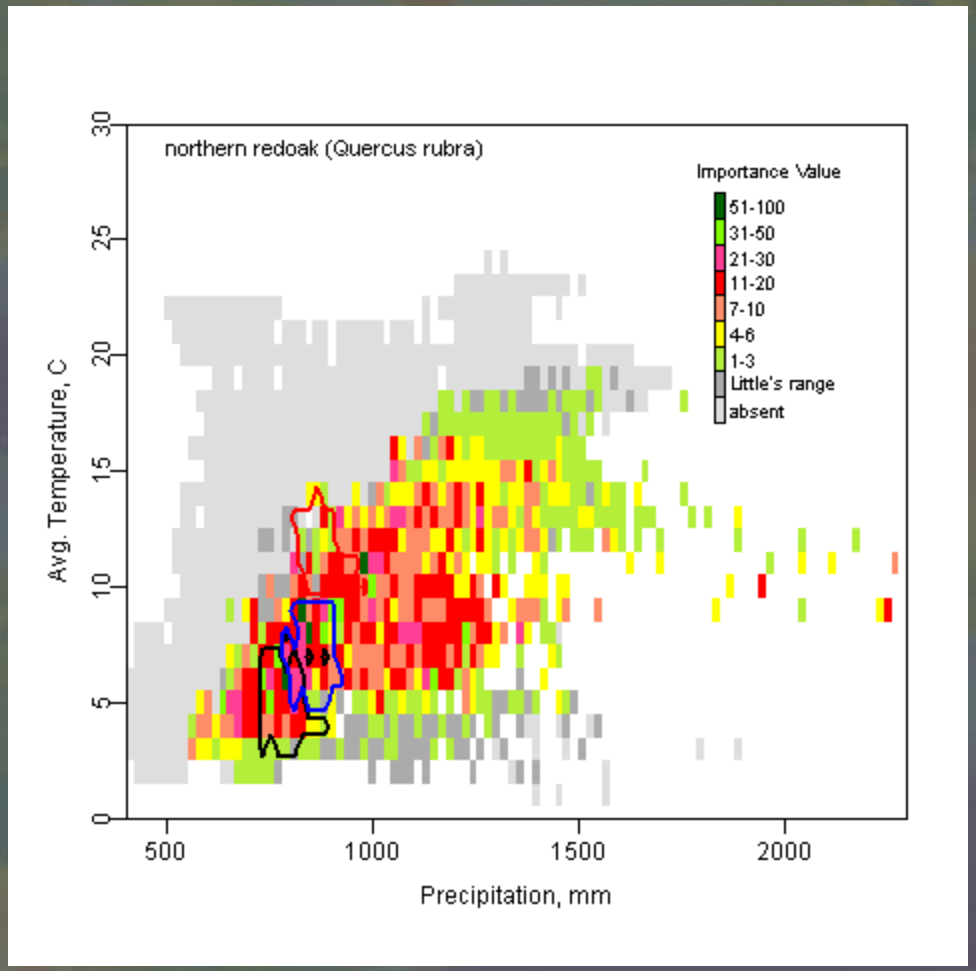


Hadhi

PCMlo

Current


red maple (Acer rubrum)
Importance Value
51-100
31-50
21-30
11-20
7-10
4-6
1-3
Little's range
absent
Avg. Temperature, C
0
5
10
15
20
25
30
500
1000
1500
2000
Precipitation, mm


northern redoak (Quercus rubra)
Importance Value
51-100
31-50
21-30
11-20
7-10
4-6
1-3
Little's range
absent
Avg. Temperature, C
0
5
10
15
20
25
30
500
1000
1500
2000
Precipitation, mm

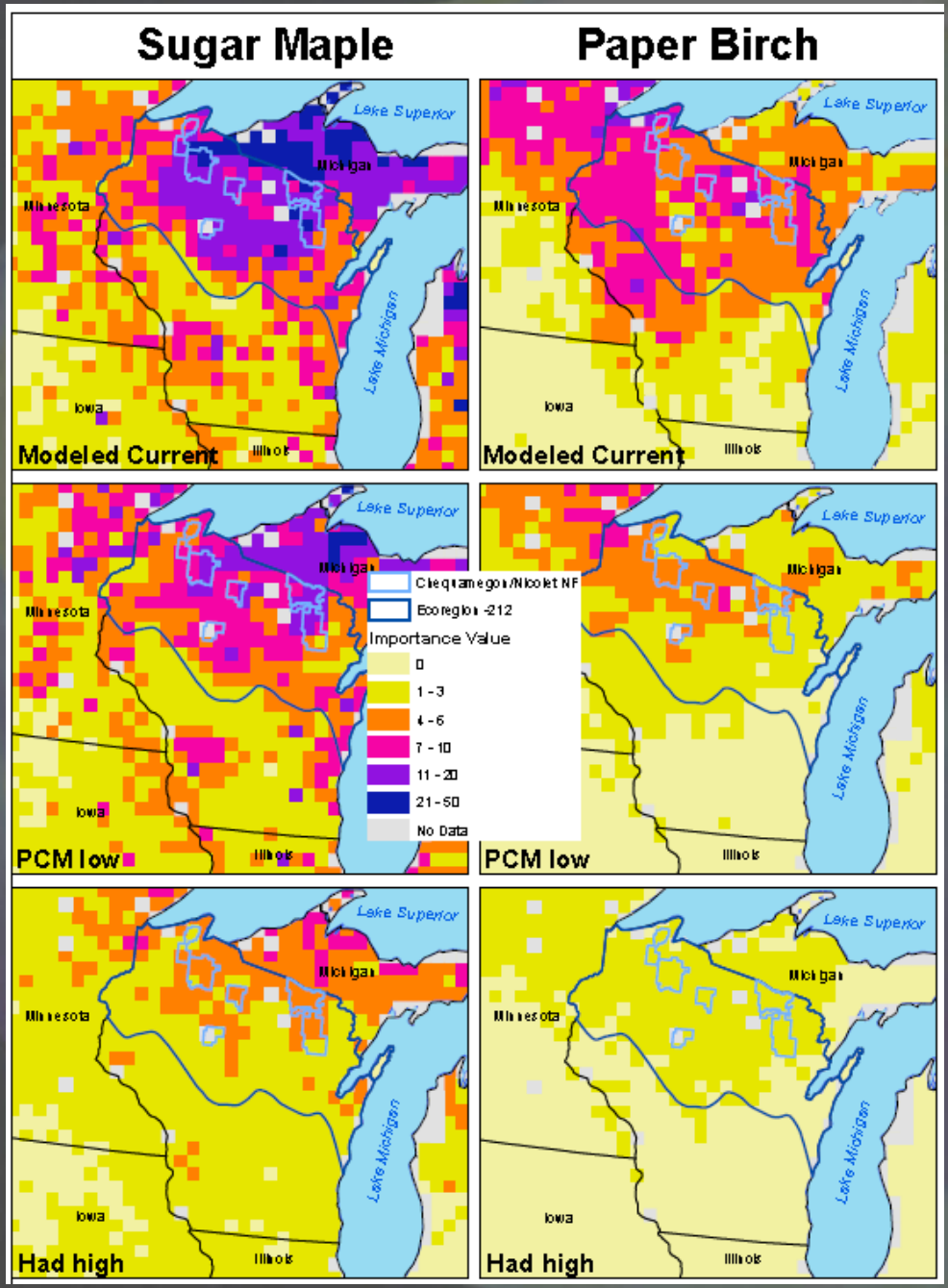
Potential Changes for Tree Species

- Evaluated 73 species from the region
- Put in to 8 classes of impacts
  - Class 1: extirpated (1 species)
  - **Class 2: large decrease (12 species)**
  - Class 3: small decrease (6 species)
  - Class 4: no change (6 species)
  - Class 5: small increase (4 species)
  - **Class 6: large increase (17 species)**
  - **Class 7: new entry-high and low emissions (11 species)**
  - Class 8: new entry-high emissions (16 species)
- Score each species for modification factors to help managers interpret potential impacts and suggest adaptation strategies → Large tables!

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	W	X	Y
1	FIA.num	Common.Name	Scientific.Name	FIA.Occ	Cur.Occ	PCMlo.I	AVElo.C	AVEhi.O	HADhi.C	Mod.R	Cur.Wl	PCMLo	AVELo.\	AVEhi.w	HADhi.\	PCMlo.I	AVElo.F	AVEhi.F	HADhi.F	class	SuitHabl	SuitHabl
2	319	MountainMaple	Acer spicatum	22	14	0	0	0	0	MR+	1	0	0	0	0	0.00	0.00	0.00	0.00	Extirp	HLE	HHE
3	95	BlackSpruce	Picea mariana	128	179	67	49	38	41	MR+	434	75	42	36	37	0.17	0.10	0.08	0.09	LgDec	HL--	HH--
4	12	BalsamFir	Abies balsamea	151	179	103	95	78	79	MR+	999	235	132	89	93	0.24	0.13	0.09	0.09	LgDec	HL--	HH--
5	375	PaperBirch	Betula papyrifera	213	224	201	199	170	173	MR+	1225	567	471	150	159	0.46	0.38	0.12	0.13	LgDec	HL-	HH--
6	371	YellowBirch	Betula alleghaniensi	162	197	138	101	70	67	MR+	358	170	104	56	54	0.48	0.29	0.16	0.15	LgDec	HL--	HH--
7	261	EasternHemlock	Tsuga canadensis	126	162	111	77	38	38	MR+	233	176	99	39	39	0.76	0.42	0.17	0.17	LgDec	HL-	HH--
8	746	QuakingAspen	Populus tremuloide	216	225	219	218	218	219	MR+	2928	1322	1283	482	499	0.45	0.44	0.16	0.17	LgDec	HL-	HH--
9	241	NorthernWhiteCedar	Thuja occidentalis	134	197	155	145	124	126	MR+	577	258	173	134	135	0.45	0.30	0.23	0.23	LgDec	HL--	HH--
10	743	BigtoothAspen	Populus grandident	195	223	222	211	155	142	MR+	499	458	344	131	118	0.92	0.69	0.26	0.24	LgDec	HL0	HH--
11	318	SugarMaple	Acer saccharum	201	223	225	225	225	225	MR+	2022	1324	1159	655	605	0.65	0.57	0.32	0.30	LgDec	HL-	HH--
12	94	WhiteSpruce	Picea glauca	119	146	127	125	100	101	MR0	203	103	109	78	79	0.51	0.54	0.39	0.39	LgDec	HL-	HH--
13	543	BlackAsh	Fraxinus nigra	198	225	223	223	216	215	MR+	856	603	580	438	445	0.70	0.68	0.51	0.52	LgDec	HL-	HH-
14	71	Tamarack	Larix laricina	142	212	191	193	184	183	MR+	415	323	293	218	221	0.78	0.71	0.53	0.53	LgDec	HL-	HH-
15	601	Butternut	Juglans cinerea	42	27	47	66	0	0	MR-	17	37	55	0	0	2.13	3.17	0.00	0.00	SmDec	HL++	HHE
16	129	EasternWhitePine	Pinus strobus	184	224	216	213	141	150	MR+	452	463	546	148	142	1.02	1.21	0.33	0.32	SmDec	HL0	HH--
17	316	RedMaple	Acer rubrum	224	225	225	225	225	225	MR+	2065	1888	1673	1172	1103	0.91	0.81	0.57	0.53	SmDec	HL0	HH-
18	977	RockElm	Ulmus thomasii	53	50	37	39	35	38	MR-	32	24	26	19	17	0.75	0.81	0.59	0.52	SmDec	HL-	HH-
19	105	JackPine	Pinus banksiana	95	175	187	202	191	202	MR+	596	470	500	372	409	0.79	0.84	0.62	0.69	SmDec	HL0	HH-
20	741	BalsamPoplar	Populus balsamifer	64	93	45	52	73	127	MR+	81	28	37	58	114	0.34	0.45	0.72	1.40	SmDec	HL--	HH0
21	763	Chokecherry	Prunus virginiana	69	96	105	144	21	26	MR-	65	77	118	4	7	1.18	1.80	0.07	0.10	NoChg	HL+	HH--
22	125	RedPine	Pinus resinosa	140	213	219	213	190	193	MR0	473	512	543	311	309	1.08	1.15	0.66	0.65	NoChg	HL0	HH-
23	833	NorthernRedOak	Quercus rubra	198	224	225	225	225	225	MR+	833	1069	1237	738	665	1.28	1.48	0.89	0.80	NoChg	HL+	HH0
24	809	NorthernPinOak	Quercus ellipsoidali	83	134	170	192	188	191	MR0	236	249	307	216	222	1.05	1.30	0.92	0.94	NoChg	HL0	HH0
25	951	AmericanBasswood	Tilia americana	196	225	225	225	225	225	MR0	631	713	847	691	661	1.13	1.34	1.10	1.05	NoChg	HL+	HH0
26	544	GreenAsh	Fraxinus pennsylvar	95	168	162	179	215	217	MR0	416	283	341	502	521	0.68	0.82	1.21	1.25	NoChg	HL-	HH+
27	541	WhiteAsh	Fraxinus americana	168	209	223	225	225	225	MR+	282	443	405	443	431	1.57	1.44	1.57	1.53	SmInc	HL+	HH+
28	701	EasternHophornbeam	Ostrya virginiana	144	223	224	225	225	224	MR0	294	325	412	457	477	1.11	1.40	1.55	1.62	SmInc	HL+	HH+
29	391	AmericanHornbeam	Carpinus carolinian	84	118	171	173	197	197	MR0	109	158	163	174	175	1.45	1.49	1.60	1.60	SmInc	HL+	HH+
30	972	AmericanElm	Ulmus americana	204	224	225	225	225	225	MR-	0	0	0	6	13	0.00	0.00	NA	NA	SmInc	HL+	HH++
31	762	BlackCherry	Prunus serotina	177	222	225	225	225	225	MR+	362	1054	981	550	418	2.91	2.71	1.52	1.16	LgInc	HL++	HH+
32	823	BurOak	Quercus macrocarp	98	167	215	225	225	225	MR0	358	545	645	796	870	1.52	1.80	2.22	2.43	LgInc	HL+	HH++
33	531	AmericanBeech	Fagus grandifolia	32	60	179	162	163	157	MR+	66	212	185	155	151	3.23	2.83	2.37	2.31	LgInc	HL++	HH++
34	802	WhiteOak	Quercus alba	93	141	225	225	225	225	MR+	328	850	992	929	862	2.59	3.02	2.83	2.63	LgInc	HL++	HH++
35	402	BitternutHickory	Carya cordiformis	53	95	166	201	225	225	MR-	81	212	285	302	302	2.63	3.53	3.74	3.74	LgInc	HL++	HH++
36	837	BlackOak	Quercus velutina	38	104	225	225	225	225	MR+	162	610	698	995	998	3.76	4.30	6.13	6.15	LgInc	HL++	HH++
37	313	Boxelder	Acer negundo	14	100	189	225	225	225	MR0	127	298	430	721	847	2.35	3.39	5.69	6.68	LgInc	HL++	HH++
38	804	SwampWhiteOak	Quercus bicolor	18	18	43	58	116	116	MR-	12	21	32	88	83	1.72	2.61	7.27	6.84	LgInc	HL++	HH++
39	407	ShagbarkHickory	Carya ovata	5	64	163	197	225	225	MR0	59	404	524	495	467	6.89	8.94	8.45	7.96	LgInc	HL++	HH++
40	317	SilverMaple	Acer saccharinum	31	102	179	222	225	225	MR0	80	385	593	682	698	4.81	7.42	8.52	8.73	LgInc	HL++	HH++
41	922	BlackWillow	Salix nigra	31	58	194	222	225	225	MR-	44	194	310	440	465	4.41	7.03	9.98	10.55	LgInc	HL++	HH++
42	975	SlipperyElm	Ulmus rubra	41	62	177	224	225	225	MR0	38	314	461	537	555	8.35	12.27	14.29	14.76	LgInc	HL++	HH++
43	742	EasternCottonwood	Populus deltoides	9	45	156	217	225	225	MR-	23	140	287	551	534	5.95	12.22	23.47	22.73	LgInc	HL++	HH++
44	641	OsageOrange	Maclura pomifera	0	7	38	84	218	225	MR0	4	22	64	216	219	5.49	16.09	53.90	54.79	LgInc	HL++	HH++
45	68	EasternRedCedar	Juniperus virginiana	5	18	166	223	225	225	MR0	16	287	782	1376	1330	18.18	49.51	87.11	84.25	LgInc	HL++	HH++
46	602	BlackWalnut	Juglans nigra	2	8	161	220	225	225	MR0	2	226	389	612	603	130.83	224.93	353.61	348.33	LgInc	HL++	HH++
47	462	Hackberry	Celtis occidentalis	2	10	118	196	225	225	MR0	0	210	428	732	744	604.04	1232.37	2105.60	2141.55	LgInc	HL++	HH++
48	830	PinOak	Quercus palustris	0	6	41	61	154	158	MR0	0	23	42	169	166	NA	NA	NA	NA	NewEntl	HLM	HHM
49	331	OhioBuckeye	Aesculus glabra	0	0	13	60	144	94	MR-	0	5	42	115	67	NA	NA	NA	NA	NewEntl	HLM	HHM
50	373	RiverBirch	Betula nigra	3	3	20	67	108	141	MR-	0	10	45	77	110	NA	NA	NA	NA	NewEntl	HLM	HHM
51	901	BlackLocust	Robinia pseudoaca	2	4	122	198	225	225	MR-	0	104	187	469	550	NA	NA	NA	NA	NewEntl	HLM	HHM
52	931	Sassafras	Sassafras albidum	0	1	50	85	177	179	MR+	0	24	51	172	176	NA	NA	NA	NA	NewEntl	HLM	HHM
53	403	PignutHickory	Carya glabra	0	1	62	87	189	198	MR+	0	44	57	171	178	NA	NA	NA	NA	NewEntl	HLM	HHM
54	682	Redmulberry	Morus rubra	1	0	93	180	225	225	MR-	0	84	280	679	711	NA	NA	NA	NA	NewEntl	HLM	HHM
55	491	FloweringDogwood	Cornus florida	0	0	31	83	160	155	MR+	0	11	55	166	162	NA	NA	NA	NA	NewEntl	HLM	HHM
56	552	Honeylocust	Gleditsia triacantho	0	2	67	140	225	225	MR-	0	49	189	482	493	NA	NA	NA	NA	NewEntl	HLM	HHM
57	621	YellowPoplar	Liriodendron tulipif	0	0	15	10	95	103	MR+	0	4	2	64	73	NA	NA	NA	NA	NewEntl	HLM	HHM
58	409	MockernutHickory	Carya tomentosa	0	1	26	44	152	167	MR+	0	7	21	135	146	NA	NA	NA	NA	NewEntl	HLM	HHM
59	404	Pecan	Carya illinoensis	0	0	0	0	50	58	MR-	0	0	0	25	32	0.00	0.00	NA	NA	NewEntl	HLE	HHM
60	921	PeachleafWillow	Salix amygdaloides	5	0	0	0	27	50	MR-	0	0	0	34	63	0.00	0.00	NA	NA	NewEntl	HLE	HHM
61	408	BlackHickory	Carya texana	0	0	0	1	152	161	MR+	0	0	0	149	166	0.00	0.00	NA	NA	NewEntl	HLE	HHM
62	766	WildPlum	Prunus americana	2	4	5	21	193	195	MR-	0	0	4	157	161	0.00	NA	NA	NA	NewEntl	HLM	HHM
63	452	NorthernCatalpa	Catalpa speciosa	0	2	0	0	11	30	MR-	0	0	0	5	18	0.00	0.00	NA	NA	NewEntl	HLE	HHM
64	806	ScarletOak	Quercus coccinea	0	0	4	7	76	76	MR+	0	1	0	51	51	NA	0.00	NA	NA	NewEntl	HLM	HHM
65	731	Sycamore	Platanus occidental	0	0	7	7	171	190	MR0	0	1	1	141	157	NA	NA	NA	NA	NewEntl	HLM	HHM
66	461	Sugarberry	Celtis laevigata	0	0	0	0	44	67	MR0	0	0	0	26	37	0.00	0.00	NA	NA	NewEntl	HLE	HHM
67	826	ChinkapinOak	Quercus muehlenbe	0	0	6	35	225	225	MR0	0	0	16	211	223	0.00	NA	NA	NA	NewEntl	HLM	HHM
68	817	ShingleOak	Quercus imbricaria	0	1	2	37	152	154	MR0	0	0	21	138	143	0.00	NA	NA	NA	NewEntl	HLM	HHM
69	471	EasternRedbud	Cercis canadensis	0	0	1	27	218	225	MR0	0	0	9	231	238	0.00	NA	NA	NA	NewEntl	HLM	HHM
70	835	PostOak	Quercus stellata	0	0	0	10	225	225	MR+	0	0	1	648	761	0.00	NA	NA	NA	NewEntl	HLM	HHM
71	824	BlackjackOak	Quercus marilandica	0	0	0	1	218	221	MR0	0	0	0	244	316	0.00	0.00	NA	NA	NewEntl	HLE	HHM
72	521	CommonPersimmon	Diospyros virginiana	0	0	0	0	30	79	MR0	0	0	0	11	45	0.00	0.00	NA	NA	NewEntl	HLE	HHM
73	693	Blackgum	Nyssa sylvatica	0	2	3	4	46	47	MR+	0	0	0	24	25	0.00	0.00	NA	NA	NewEntl	HLE	HHM

Losers

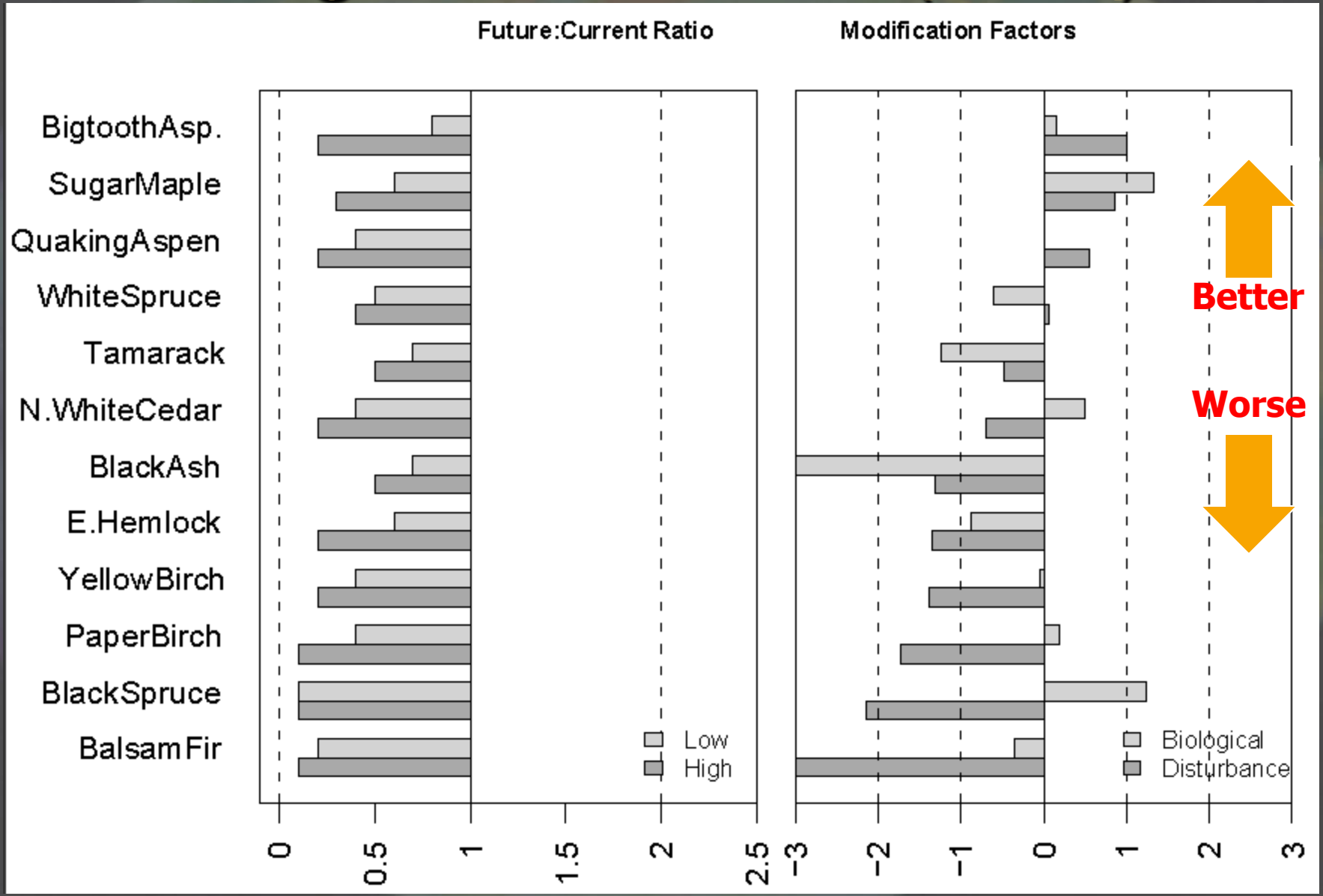
Gainers

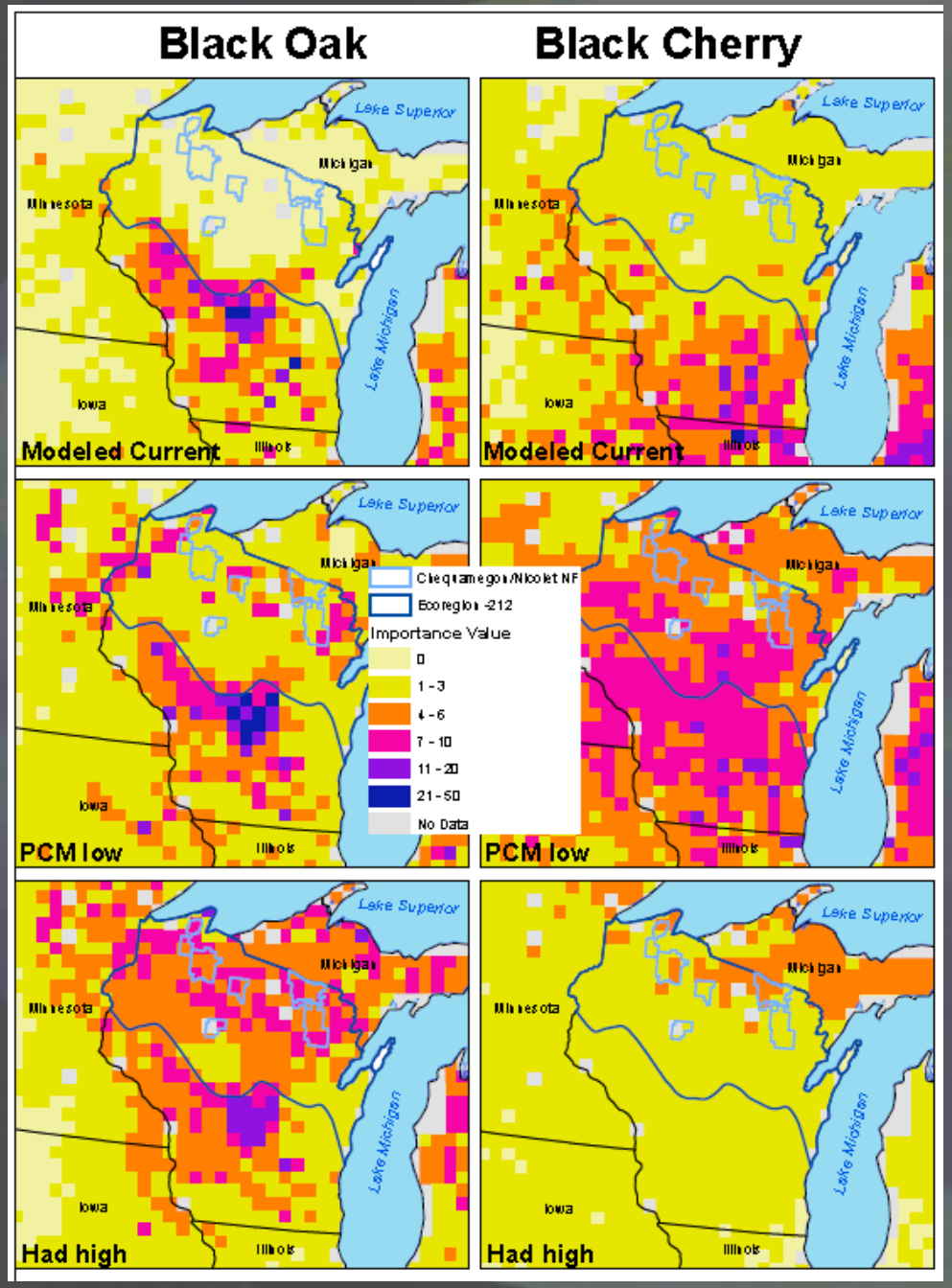


Class 2,
Large Decreasers

(especially under Had High scenario of climate change)

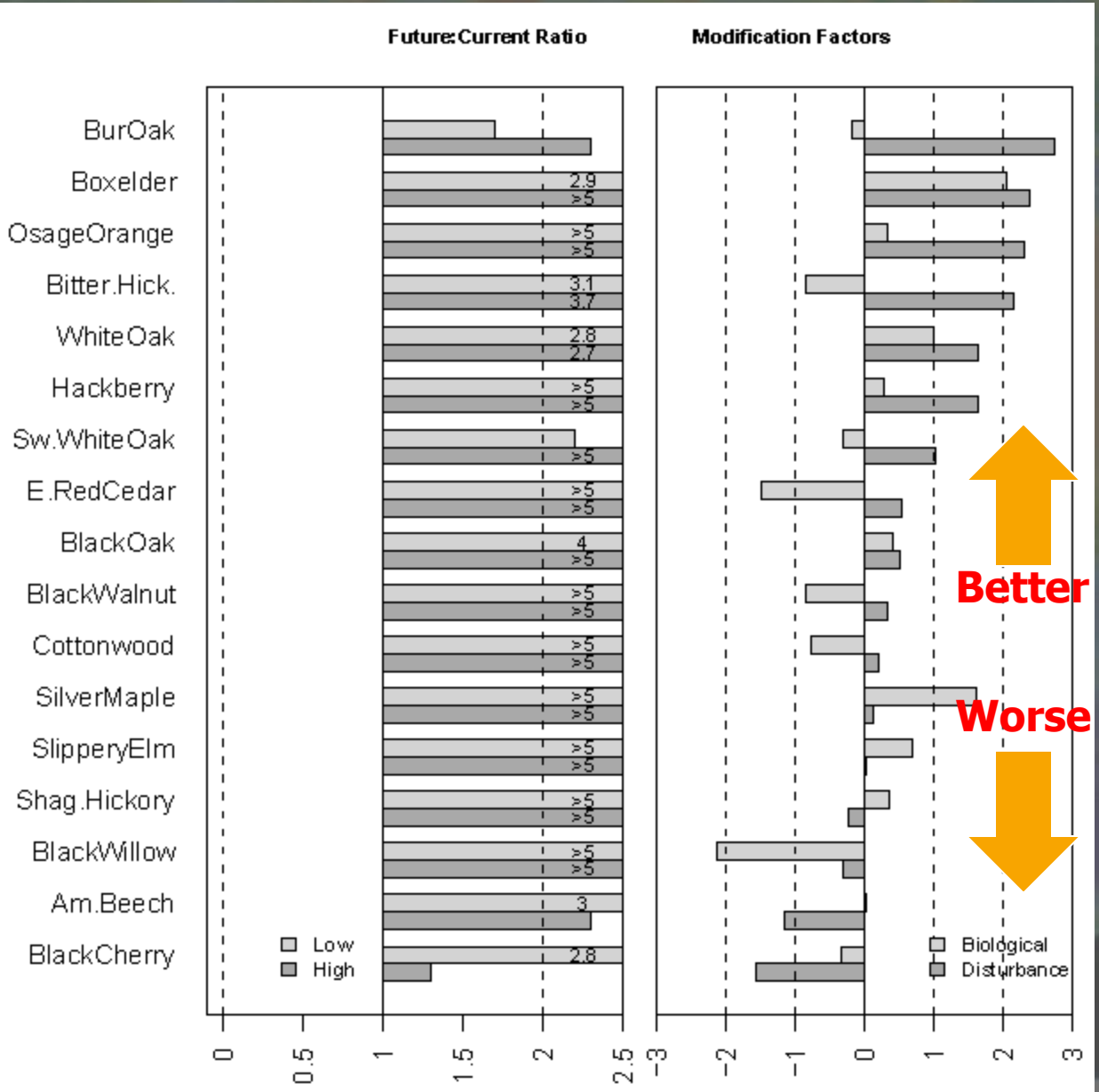
Large Decreasers (Cl. 2)

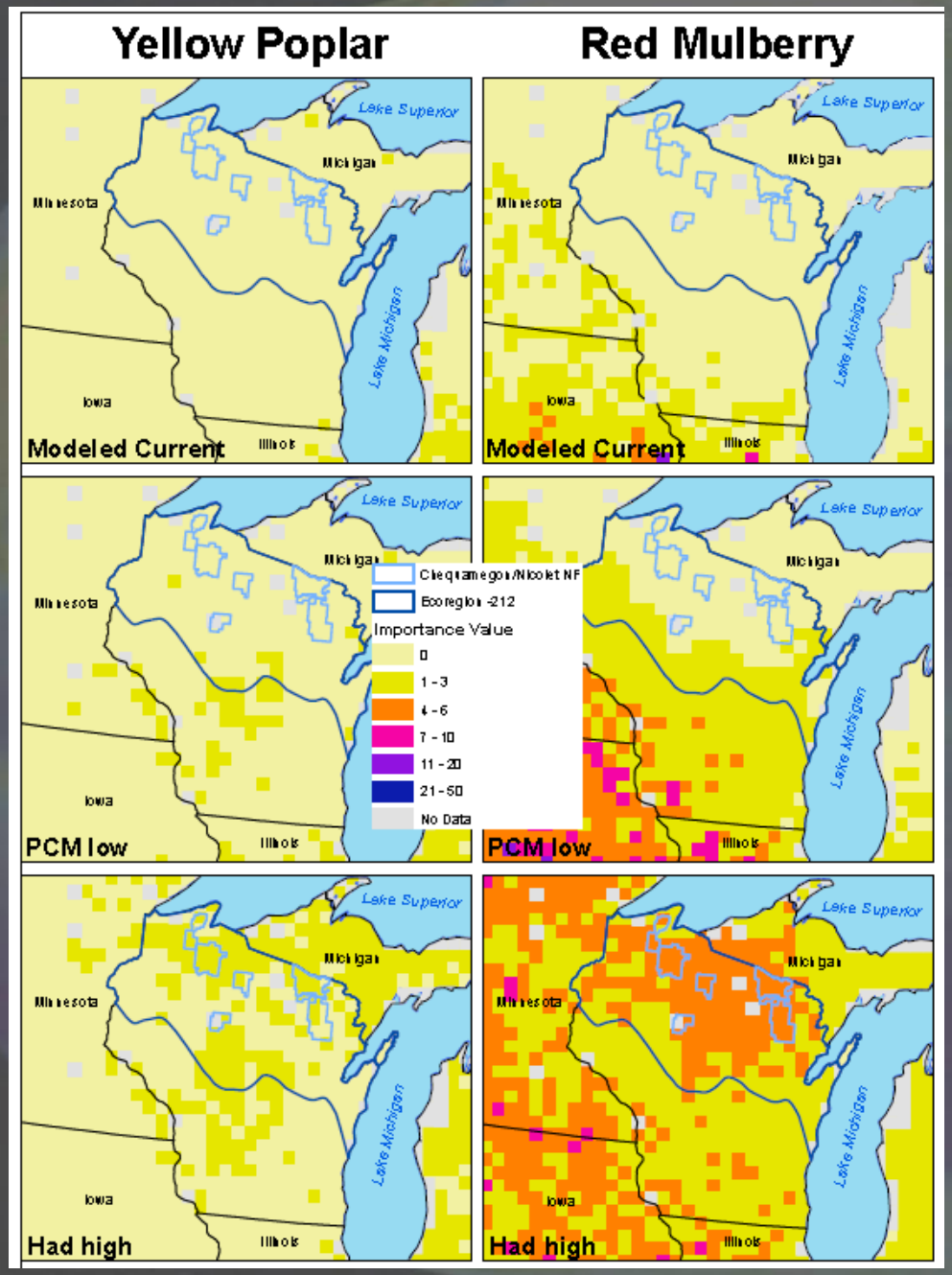




Class 6,
Large Increasers

Large Increasers (Cl. 6)

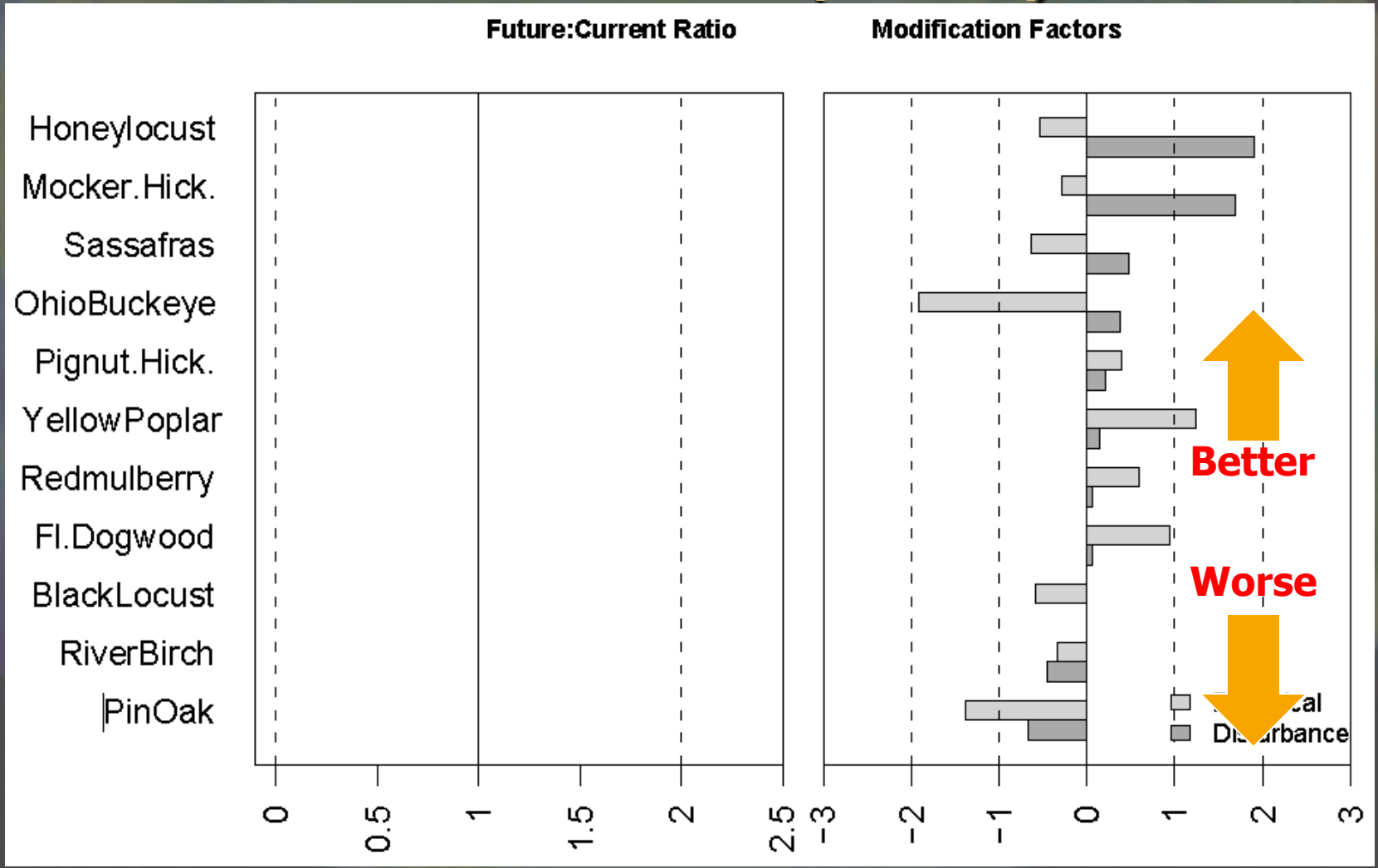




Class 7
New Migrants,

Any scenario
of climate change.

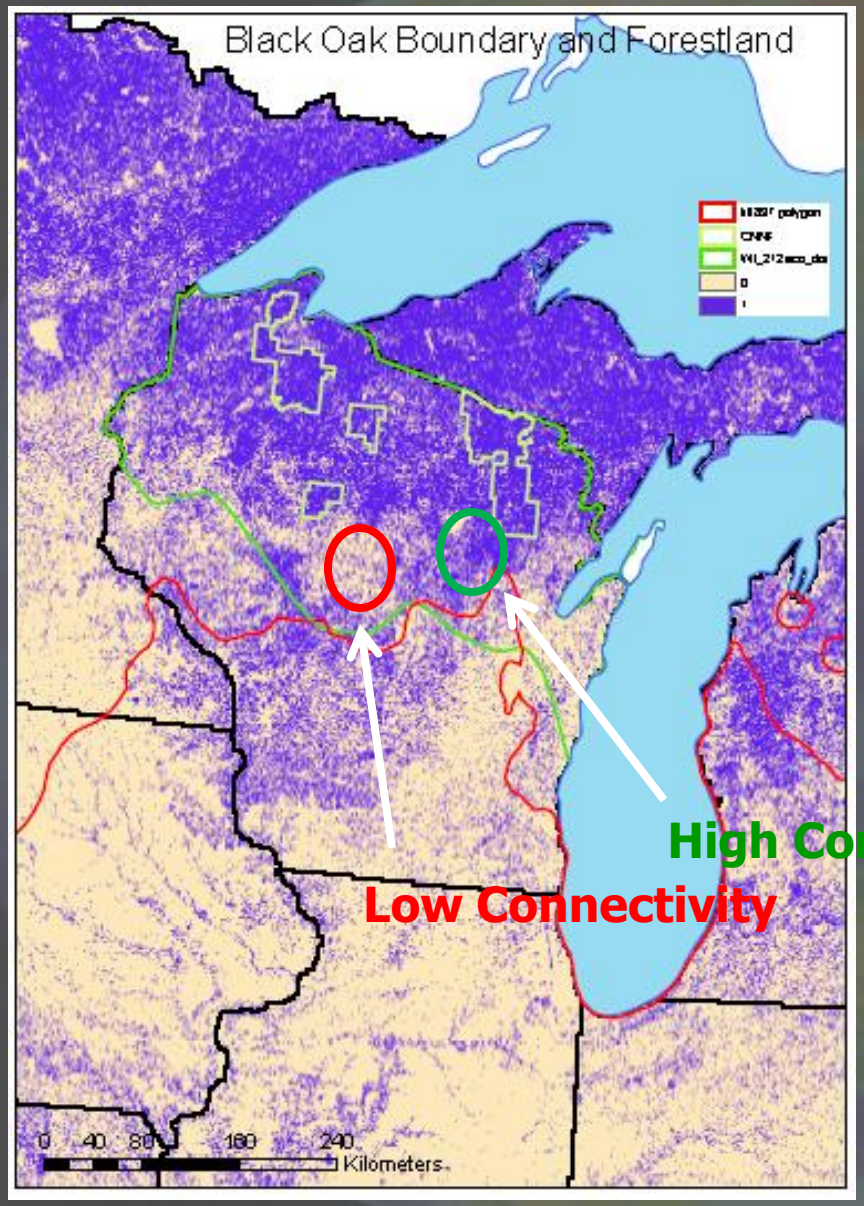
New Migrants, low or high emissions (Cl. 7)

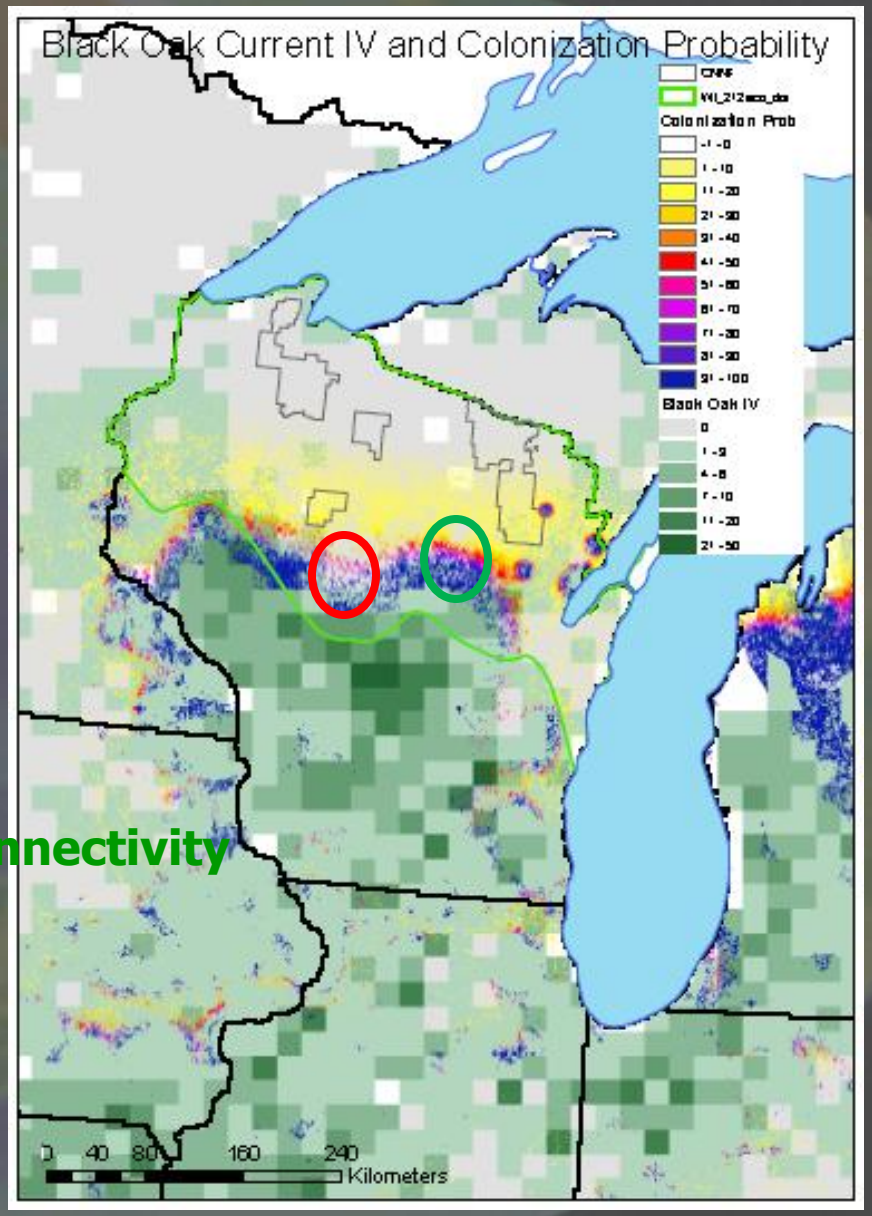


Overall habitat change for 7 species groups by GCM/emission

species	Current Habitat habitat total	Change in Habitat PCMlo	Hadhi
balsam fir	4.8	-3.6	-4.4
aspen	16.8	-8.2	-14.3
paper birch	6	-3.3	-5.4
jack pine	3.1	-0.8	-1.5
white and red pine	4.7	0	-2.9
all oak	10.5	6.8	11.3
northern hardwood	17	-3.1	-10

SHIFT (preliminary):Black oak potential migration by 2100





Forest Density (NLCD data 2000)

Shift (Preliminary)Output on Current Black Oak IV

Potential Changes in Forest Birds

common name	migratory guild	Habitat guild	ModRel	Current	High em ratio	Low em ratio	class
Swainson's Thrush	Neotropical	Forest	High	8	0	0.013	Extirp
Dark eyed junco	Short distance	Forest	High	15.8	0.038	0.271	LgDec
Evening Grosbeak	Short distance	Forest	High	27.6	0.043	0.165	LgDec
Winter Wren	Short distance	Forest	High	75.1	0.062	0.181	LgDec
Hermit Thrush	Short distance	Forest	High	99.3	0.092	0.222	LgDec
Black-throated Green Warbler	Neotropical	Forest	High	77.9	0.105	0.235	LgDec
Canada Warbler	Neotropical	Forest	High	47.6	0.116	0.228	LgDec
Magnolia Warbler	Neotropical	Forest	High	33.8	0.126	0.235	LgDec
Purple Finch	Short distance	Shrubland	High	[illegible]	0.128	0.31	LgDec
Yellow-rumped Warbler	Short distance	Forest	High	94.3	0.146	0.27	LgDec
Blackburnian Warbler	Neotropical	Forest	Medium	53.9	0.157	0.24	LgDec
Red-breasted Nuthatch	Short distance	Forest	High	89.4	0.161	0.35	LgDec
White-throated Sparrow	Short distance	Shrubland	High	124.6	0.161	0.307	LgDec
Yellow-bellied Sapsucker	Short distance	Forest	High	105.5	0.162	0.357	LgDec
Nashville Warbler	Neotropical	Shrubland	High	118.8	0.166	0.34	LgDec
Veery	Neotropical	Forest	High	163.5	0.169	0.394	LgDec
Mourning Warbler	Neotropical	Shrubland	High	132.7	0.19	0.362	LgDec
Brown Creeper	Short distance	Forest	Medium	25.8	0.211	0.451	LgDec
Golden-winged Warbler	Neotropical	Shrubland	Medium	70.1	0.241	0.444	LgDec
Black-and-white Warbler	Neotropical	Forest	High	118.8	0.247	0.423	LgDec
Blue-headed Vireo	Neotropical	Forest	High	47	0.248	0.386	LgDec
Northern Waterthrush	Neotropical	Forest	Medium	42.2	0.25	0.438	LgDec
Clay-colored Sparrow	Neotropical	Shrubland	High	116	0.285	0.277	LgDec
Broad-winged Hawk	Neotropical	Forest	Low	59.8	0.313	0.497	LgDec
Ruffed Grouse	Resident	Forest	Low	42.5	0.255	0.722	SmDec
Black-throated Blue Warbler	Neotropical	Forest	High	7.9	0.336	0.531	SmDec
Ovenbird	Neotropical	Forest	High	167.8	0.337	0.615	SmDec
Yellow Warbler	Neotropical	Shrubland	High	[illegible]	0.339	0.906	SmDec
Song Sparrow	Short distance	Shrubland	High	187.8	0.377	0.991	SmDec
American Redstart	Neotropical	Forest	High	129.5	0.383	0.658	SmDec
Pine Warbler	Short distance	Forest	High	65.8	0.413	0.539	SmDec
Black-billed Cuckoo	Neotropical	Forest	High	101.2	0.482	0.801	SmDec
Pileated Woodpecker	Resident	Forest	Medium	93.4	0.612	0.617	SmDec
Gray Catbird	Neotropical	Shrubland	High	170.6	0.61	1.061	NoChg
Red-eyed Vireo	Neotropical	Forest	High	181.1	0.626	0.818	NoChg
American Goldfinch	Short distance	Shrubland	High	185.3	0.675	1	NoChg
Common Yellowthroat	Neotropical	Shrubland	High	186.9	0.693	0.996	NoChg
Black-capped Chickadee	Resident	Forest	High	176	0.714	0.889	NoChg
Rose-breasted Grosbeak	Neotropical	Forest	High	185.2	0.749	0.927	NoChg
House Wren	Neotropical	Shrubland	High	163.9	0.792	1.097	NoChg
Wood Thrush	Neotropical	Forest	High	107.7	0.889	0.998	NoChg
Indigo Bunting	Neotropical	Shrubland	High	177.5	0.953	1.033	NoChg
Warbling Vireo	Neotropical	Forest	High	130.5	0.958	1.107	NoChg
White-breasted Nuthatch	Resident	Forest	High	126.8	0.986	1.136	NoChg
Yellow-throated Vireo	Neotropical	Forest	Medium	88	0.995	1.083	NoChg
Ruby-throated Hummingbird	Neotropical	Forest	Low	62	1.016	0.894	NoChg
Downy Woodpecker	Resident	Forest	Low	123	1.031	1.058	NoChg
Brown Thrasher	Short distance	Shrubland	High	145.4	1.1	1.099	NoChg
Least Flycatcher	Neotropical	Forest	Medium	33.5	1.155	0.989	NoChg
Northern Parula	Neotropical	Forest	Medium	40.7	1.219	0.22	NoChg
Eastern Towhee	Short distance	Shrubland	High	79.9	1.239	1.275	NoChg
Field Sparrow	Short distance	Shrubland	High	79.8	1.938	1.984	LgInc
Whip-poor-will	Neotropical	Forest	Low	19	2.279	1.197	LgInc
Eastern Wood-Pewee	Neotropical	Forest	Low	39.7	2.456	1.717	LgInc
Northern Cardinal	Resident	Shrubland	High	[illegible]	[illegible]	2.495	LgInc
Yellow-billed Cuckoo	Neotropical	Forest	High	33.7	4.1	2.207	LgInc
Blue-winged Warbler	Neotropical	Shrubland	Medium	3.8	6.527	7.502	LgInc
Red-bellied Woodpecker	Resident	Forest	High	17	7.68	5.886	LgInc
Blue-gray Gnatcatcher	Neotropical	Forest	High	4.7	16.096	7.012	LgInc
Prairie Warbler	Neotropical	Shrubland	High	0	NA	NA	NewEntBoth
Tufted Titmouse	Resident	Forest	High	0	NA	NA	NewEntBoth
Prothonotary Warbler	Neotropical	Shrubland	Medium	0	NA	NA	NewEntBoth
Acadian Flycatcher	Neotropical	Forest	Medium	0	NA	NA	NewEntBoth
Kentucky Warbler	Neotropical	Forest	High	0	NA	NA	NewEntBoth
Hooded Warbler	Neotropical	Forest	Medium	0	NA	NA	NewEntBoth
Blue Grosbeak	Neotropical	Shrubland	High	0	NA	NA	NewEntBoth
White-eyed Vireo	Neotropical	Shrubland	High	0	NA	NA	NewEntBoth
Carolina Wren	Resident	Shrubland	High	0	NA	NA	NewEntBoth
Chuck-Will's Widow	Neotropical	Forest	High	0	NA	0	NewEntHi
Summer Tanager	Neotropical	Forest	High	0	NA	0	NewEntHi
Worm-eating Warbler	Neotropical	Forest	Low	0	NA	0	NewEntHi
Yellow-throated Warbler	Neotropical	Forest	Low	0	NA	0	NewEntHi
Painted Bunting	Neotropical	Shrubland	High	0	NA	0	NewEntHi

Extirpated

Large Decrease

Small Decrease

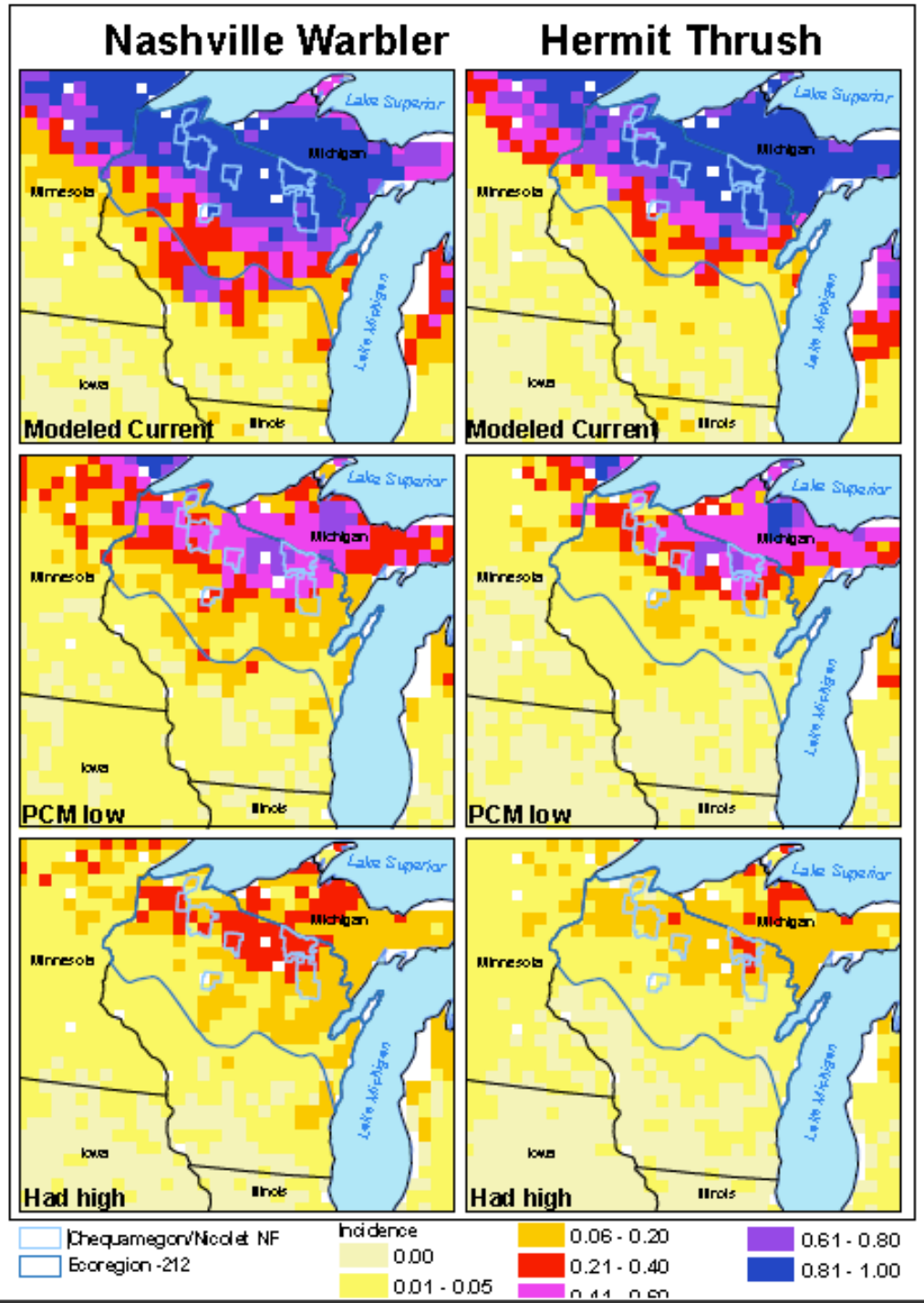
No Change

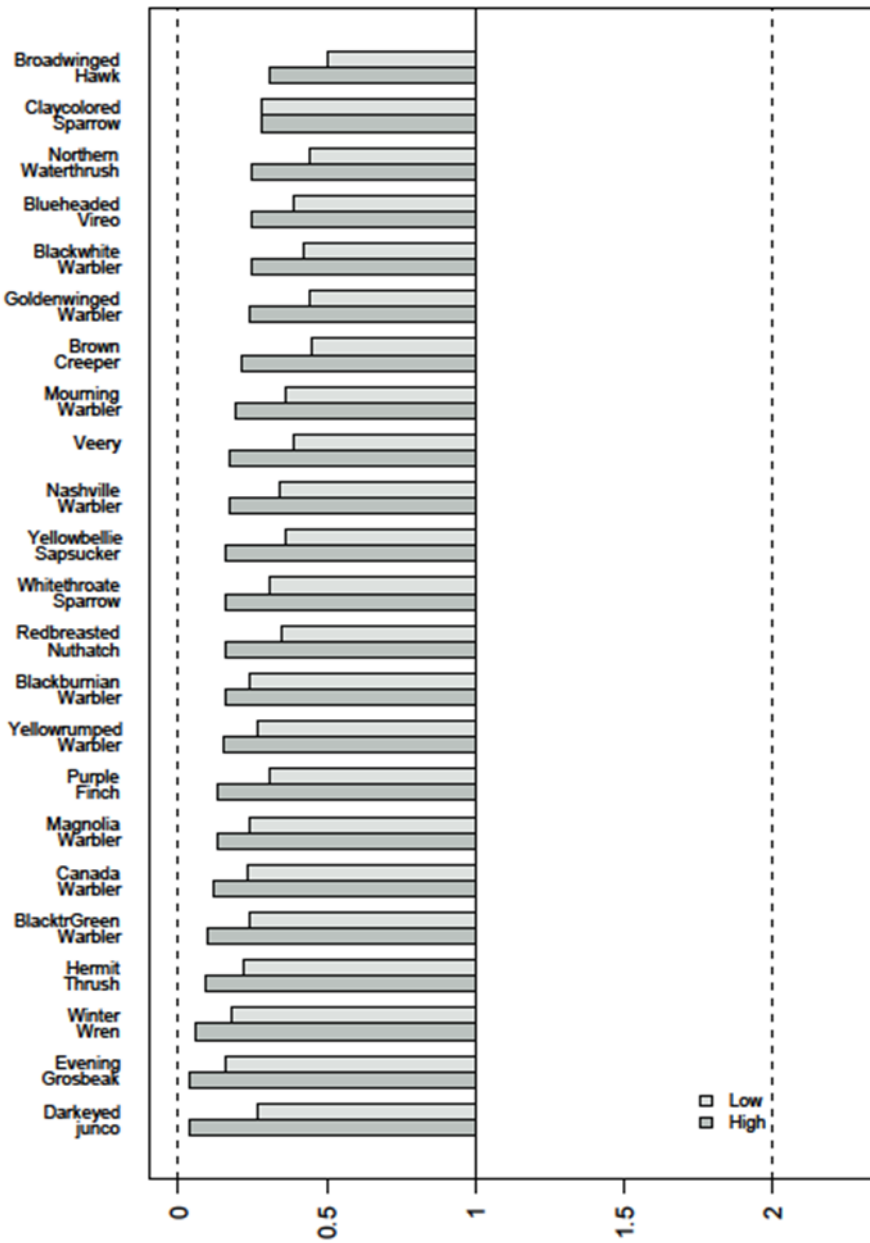
Large Decrease

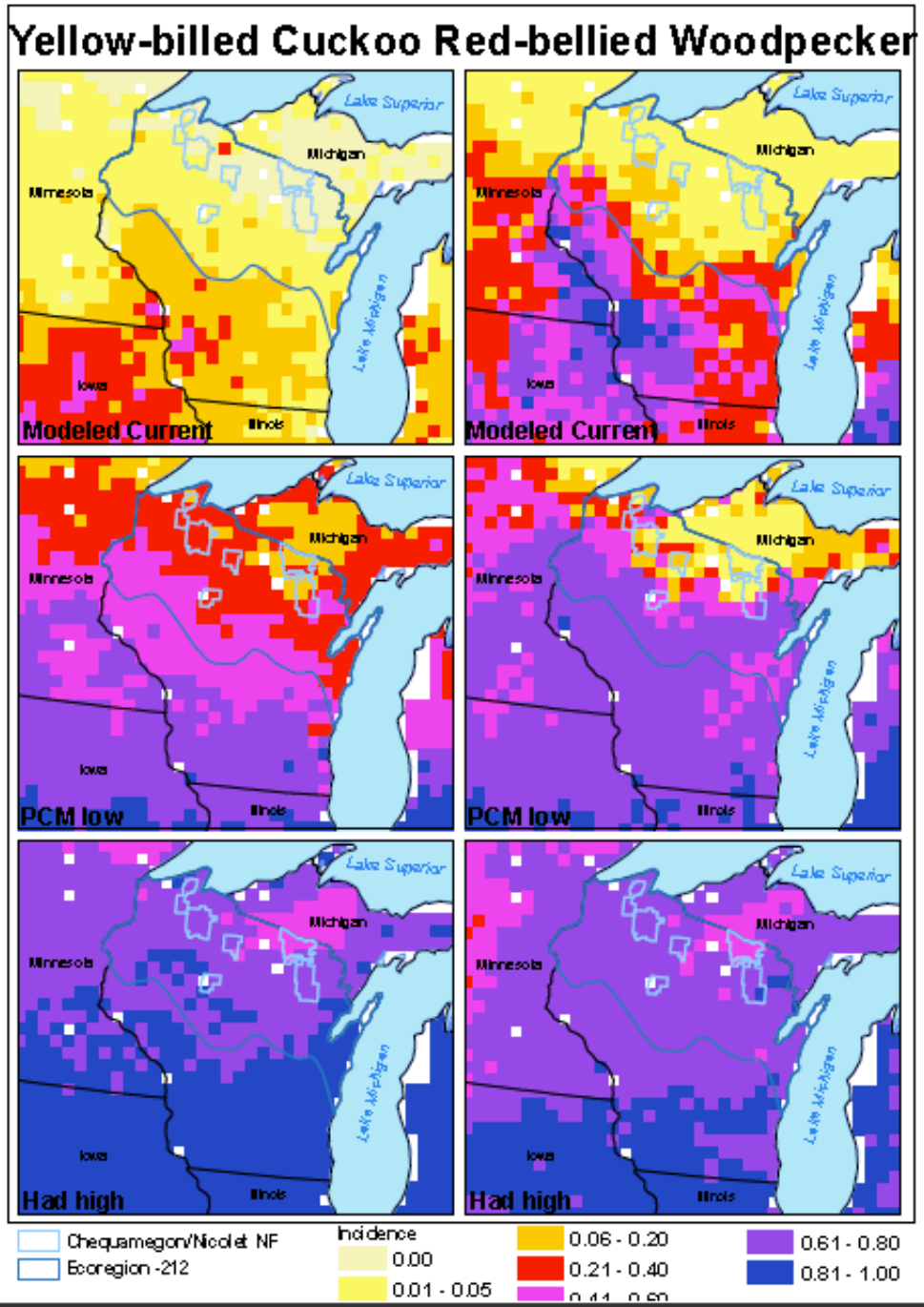
New Entry - Both

New Entry – High Emissions

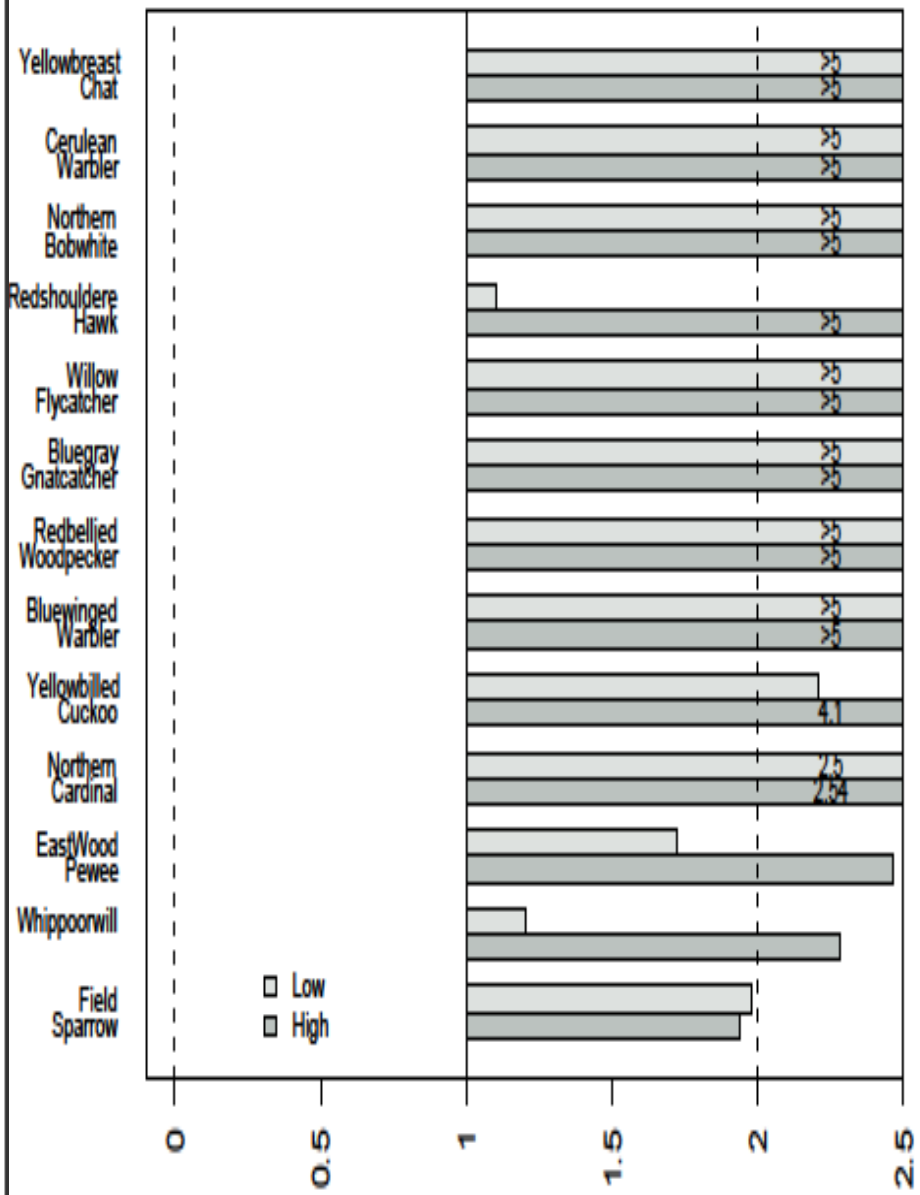
Large Decreasers (Class 2)







Large Increasers (Class 6)



Biological Effects in N Wisconsin

The above conditions will result in some fairly **dramatic biologic effects** :

- For 73 modeled tree species, most will have their suitable habitat shift north (LU=low uncertainty)
- 21 species were modeled to increase habitat, 19 decrease, 6 no change, and 27 may have habitat move in from the south (HU=high uncertainty)
- Some key dominant and iconic species, like sugar maple, balsam fir, paper birch, and aspen, are likely to decline in habitat (MU=medium uncertainty)
- Major associates of all forest types, except oak-hickory, could see declines in habitat (HU)

Biological Effects (2)

- Some species, like red maple, have relatively greater biological capacity to deal with disturbance and other changes, and will likely do much better than the models predict; others, like balsam fir, will likely do worse (MU)
- Changes in species composition could happen quickly (via disturbance) or, more likely, slowly, as trees live a long time and there will long lag times (HU)
- There could also be niche gaps open up during transitions which will invite non-native invasives along with native invaders (HU)

Biological Effects (3)

- Fragmented habitats slow the potential for unassisted migration of species (MU)
- Rare species are much more difficult to model, but some proportion of them will be more severely threatened with climate change (LU)
- Of the 77 forest and shrubland birds currently or with potential future habitat in the region, 23 show large declines in habitat, 13 show large increases, and 14 species may have habitat move into the region.
- Many of the 'loser' species show associations with boreal forest tree species (e.g. evening grosbeak and mourning warbler) that are projected to decline in the region.

Ecosystem Vulnerabilities

The potential changes in species composition may thus lead to a number of **ecosystem vulnerabilities:**

- Lowland hardwood forests (presently dominated by black ash) will be disrupted from drying and especially the emerald ash borer, and probably converted to red maple (MU)
- Lowland conifer forests (e.g., balsam fir), may be stressed more by dry late summers, disrupting that entire ecosystem (HU)
- Several ecosystems with species that have been recently declining (e.g., hemlock, paper birch, white spruce) will likely continue to decline (LU)

Guidelines for applying our modeling approach

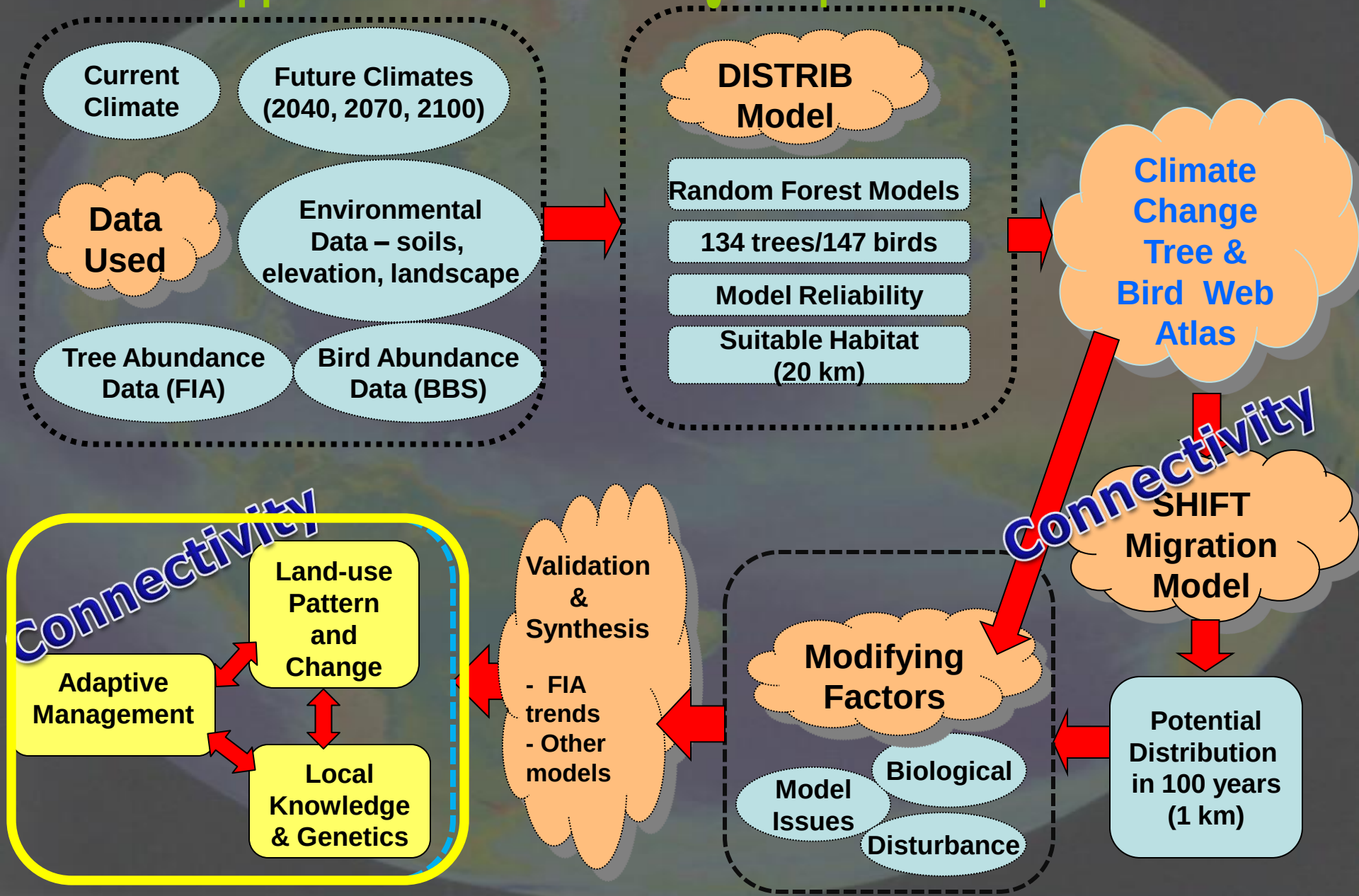
- With climate change predictions, plan for the worst (high emissions) and encourage lower emissions.
- Pay attention to the reliability of each species model – and regardless, there still will be errors!
- Use these models as guidelines for regional trends and learn which species are in, or could be in, your location now – they may provide a regional context for finer scale modeling and experiments
- Use modifying factors to help understand the potential for change for each species
- Concentrate on the factors you can do something about and the management implications relevant to those species

Management Implications

Potential **management implications** resulting from the above trends are many, a few of which include:

- Special attention to encouragement of corridors and stepping stones for movement of organisms generally northward
- Special attention to refugia which may allow persistence of species which are losing suitable habitat. Possibilities include hydrology management for lowland forests, careful management of mesic coves, and facilitated regeneration into slightly wetter habitats within the same landscapes.
- In some cases, a triage of rare species will indicate the battle to save the species in that area is not tenable.
- Additional attention and costs may be required to maintain forest health due to increased stress and disturbances (e.g., insect pests, diseases, fire, ice, drought).
- This is a terrific application for adaptive management!

Our Approach: Climate Change Impacts on Species



Thank you!

For further information, consult our web atlas (www.nrs.fs.fed.us/atlas)

or contact me

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