

Climate Change and Forest Biodiversity:

A Vulnerability Assessment and Action Plan for National Forests in the Pacific Northwest

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THE TEAM

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THE ISSUE

How can national forests in the PNW conserve biodiversity and increase resilience, given predicted changes in climate?



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GOAL AND OBJECTIVES

GOAL:

To conduct an assessment of the vulnerability of individual forest tree species to climate change

RATIONALE:

Understanding which tree species are most vulnerable will assist managers in efficiently allocating limited resources to the management of these species.



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WHY FOREST TREES?

The potential effects of climate change on forest trees is important because:

- Trees provide stand structure
- Trees dictate the composition of plant communities
- Many tree species have high economic or cultural values
- Trees comprise most of the biomass production and aboveground carbon storage on national forests
- Trees are long-lived with long generational intervals so they are slower to adapt and migrate



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VULNERABILITY ASSESSMENT (ForGRAS model)

- Spreadsheet model
- Quantitatively rate and rank tree species based on predicted climate change vulnerability
- Vulnerability score of 0 to 100 (100=most vulnerable)
- Modified for our objectives and region
 - We chose variables based on accepted scientific data
 - Assumed increased temperature & summer drought; did not include large-scale disturbances



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FIVE RISK FACTORS (ForGRAS Model)

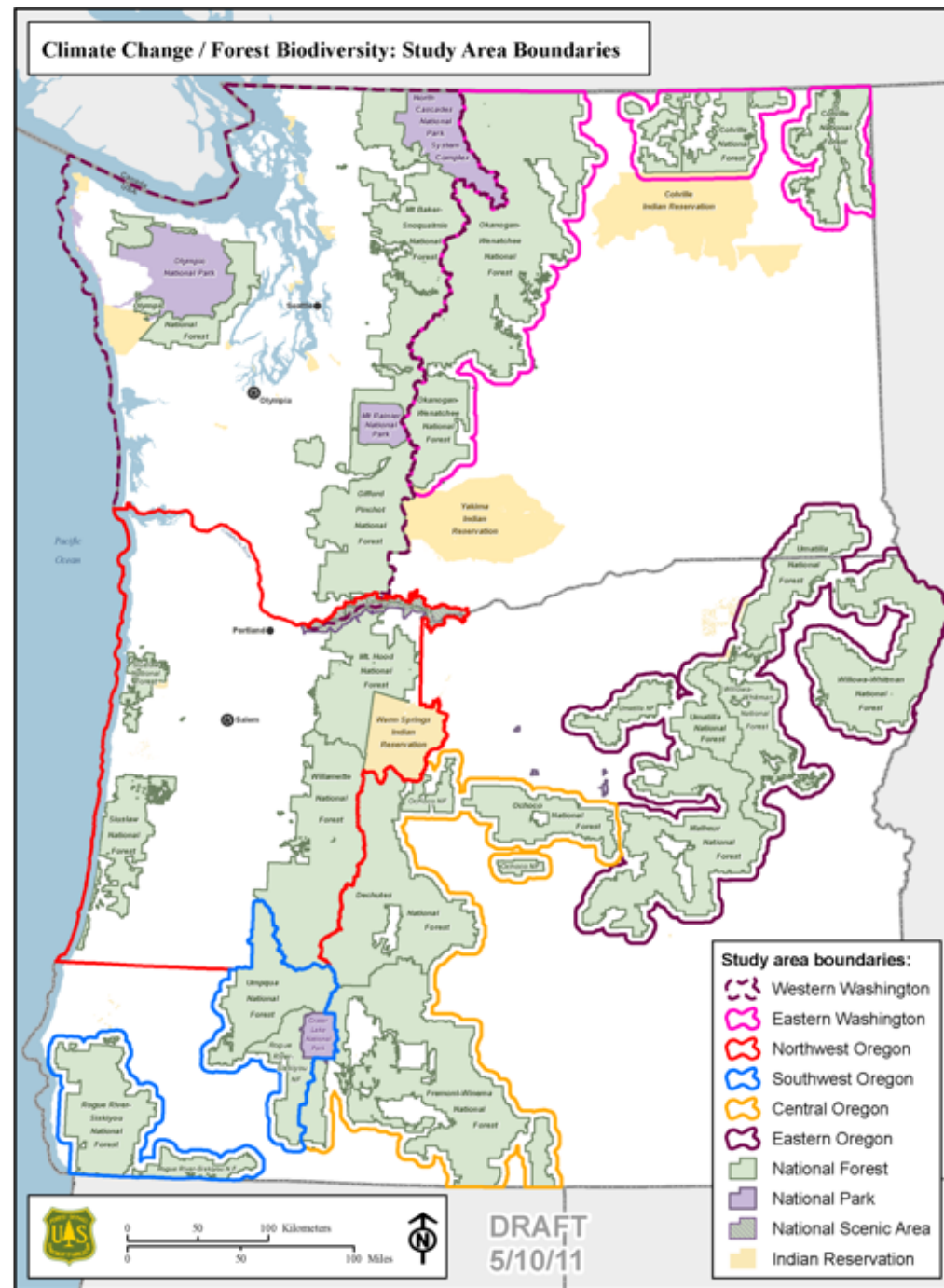
- **Distribution**
frequency of occurrence, distribution of occurrences
- **Reproductive Capacity**
seed production, min. seed-bearing age, seed dispersal distance
- **Adaptive Genetic Variation**
generalist vs. specialist, disjunct populations, pollen dispersal
- **Habitat Affinities**
Mean elevation, drought tolerance, successional stage
- **Insect and Disease Threats**
Identified by USFS Forest Health Protection pathologists and entomologists



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SUBREGIONAL ASSESSMENTS

Subregion	National Forests
W WA	ONF, MBS, GP
NW OR	MTH, SIU, WIL
E WA	COL, OKA-WEN
E OR	MAL, UMA, W-W
C OR	DES, OCH, FRE-WIN
SW OR	UMP, ROR-SIS



COMPILING INFORMATION

- Tree species grouped for analysis:
 - Group 1 – common overstory species
 - Group 2 – limited distribution or midstory/understory
 - Group 3 – rare
- Quantitative vulnerability assessment model applied only to Group 1 to investigate sources of vulnerability and rank species for relative risk.



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57 native tree species of OR and WA

Organized
into 3 groups

List of native tree species and analysis groups for the six subregional study areas in Washington and Oregon ¹						
Common name	Subregional study area					
	Western Washington	Northwestern Oregon	Eastern Washington	Eastern Oregon	Central Oregon	Southwestern Oregon
Alaska yellow-cedar	1	1	1	3		3
Baker cypress						3
Bigleaf maple	1	1	1			1
Bitter cherry	2	2	2	2	2	2
Black cottonwood	1	1	1	1	2	2
Black hawthorn	2					
Brewer spruce						3
California black oak						1
Canyon live oak						1
Cascara	2	2	2	2	2	2
Coast redwood						3
Douglas-fir	1	1	1	1	1	1
Engelmann spruce	1	1	1	1	1	1
Golden chinquapin	3	2			2	2
Grand fir	1		1			
Grand fir-white fir complex		1		1	1	1
Incense cedar		2			1	1
Jeffrey pine						1
Knobcone pine						1
Limber pine				3		
Lodgepole pine, Sierra						
Lodgepole pine	2	1	1	1	1	1
Mountain hemlock	1	1	1	3	1	1
Netleaf hackberry			2	2		
Noble fir	1	1	1			
Noble fir-Shasta red fir complex					1	1
Oregon ash	2	2				2
Oregon crab apple	2	2				
Oregon myrtle						2
Oregon white oak	2	1	1			1
Pacific dogwood	2	2				2
Pacific madrone	2	2				1
Pacific silver fir	1	1	1		1	1
Pacific willow	2	2	2	2	2	2
Pacific yew	2	2	2	2		2
Paper birch	2		1	2		
Peachleaf willow				2		
Ponderosa pine	3	1	1	1	1	1
Port-Orford-cedar						1
Quaking aspen	2		1	1	2	2
Red alder	1	1	2	2	2	1
Rocky Mountain juniper	3		2	3		
Rocky Mountain maple	2	2	2	2	2	2
Scouler's willow	2	2	2	2	2	2
Shore pine	2	1				1
Sitka spruce	1	1				3
Subalpine fir	1	1	1	1	1	1
Subalpine larch			1			
Sugar pine		1			1	1
Tanoak						1
Water birch			2	2		
Western hemlock	1	1	1		1	1
Western juniper				1	1	
Western larch		1	1	1	1	
Western redcedar	1	1	1			1
Western white pine	1	1	1	1	1	1
White alder		2		2		2
Whitebark pine	3	1	1	1	1	1

¹ Analysis group numbers are: group 1 (major canopy species), 2 (subcanopy or minor canopy species), or 3 (rare species).

CALCULATION SPREADSHEETS

Distribution Risk Factor							
Tree species	User-entered data			Automatically calculated scores			
	Frequency of occurrence (% of plots)	Proportion of canopy trees (%)	Distribution within study area	Frequency of occurrence	Proportion of canopy trees	Raw factor score	Scaled factor score
Alaska yellow-cedar	0.2	0.0	50	100	100	83	91
Bigleaf maple	20.6	24.9	0	77	64	47	50
Black cottonwood	1.5	19.2	0	98	72	57	61
Douglas-fir	88.0	62.7	0	0	9	3	0
Engelmann spruce	1.8	7.6	50	98	89	79	86
Grand fir	9.6	27.0	0	89	61	50	53
Lodgepole pine	2.9	22.1	50	97	68	72	78
Mountain hemlock	7.2	34.2	50	92	50	64	69
Noble fir	7.6	21.0	25	91	70	62	67
Oregon white oak	5.2	46.9	25	94	32	50	54
Pacific silver fir	11.0	34.5	25	88	50	54	58
Ponderosa pine	5.6	44.5	25	94	36	51	55
Red alder	32.0	34.9	0	64	50	38	39
Shore pine	0.4	69.1	75	100	0	58	63
Sitka spruce	7.2	23.1	50	92	67	70	76
Subalpine fir	1.4	24.9	50	99	64	71	77
Sugar pine	0.7	1.9	50	99	97	82	90
Western hemlock	46.4	30.7	0	47	56	34	36
Western larch	1.1	4.8	75	99	93	89	98
Western redcedar	21.5	11.9	0	76	83	53	57
Western white pine	4.1	8.8	50	96	87	78	85
Whitebark pine	0.1	1.3	75	100	98	91	100

Northwest Oregon subregion

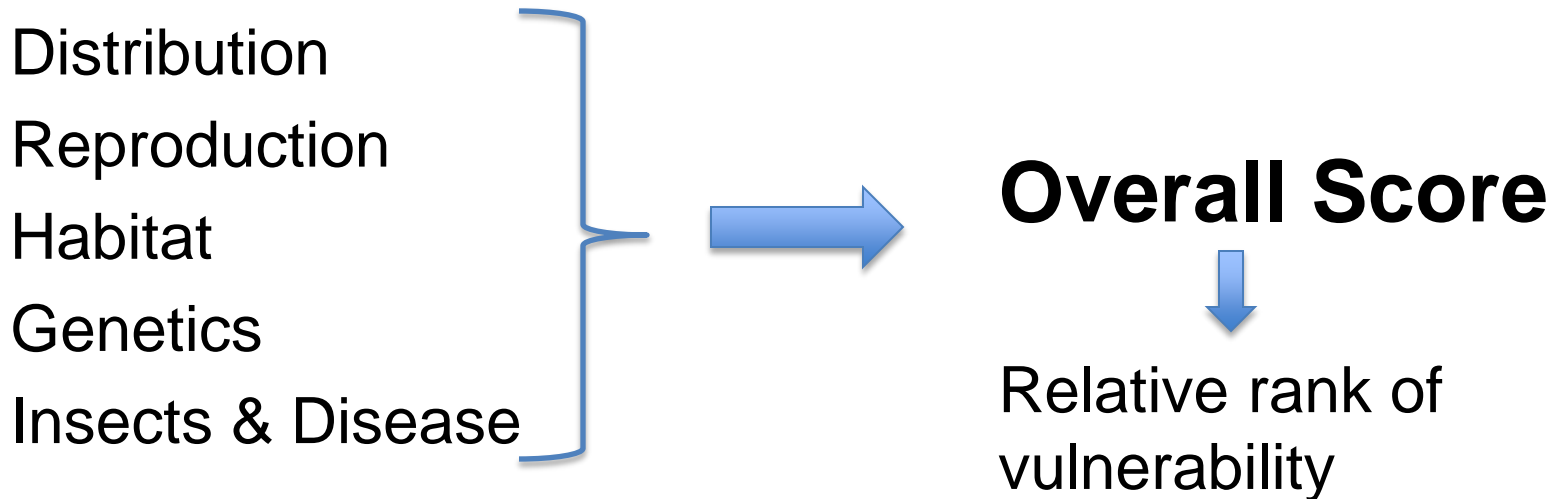
CALCULATION SPREADSHEETS

Habitat Risk Factor										
	User-entered data (for reference; values are not used in calculations)				Automatically calculated	User-entered ratings			Automatically calculated scores	
Tree species	Mean elevation of FIA plots (ft)	Successional Stage	Habitat specificity	Drought tolerance	Elevation score	Successional stage	Habitat specificity	Drought tolerance	Raw factor score	Scaled factor score
Alaska yellow-cedar	4,367	Early to late	Medium	Medium	73	50	50	50	56	64
Bigleaf maple	1,115	Early to late	Low	Low	17	50	0	100	42	43
Black cottonwood	1,509	Early	Medium	Low	24	0	50	100	43	46
Douglas-fir	1,868	Early to late	Low	Medium	30	50	0	50	33	30
Engelmann spruce	4,219	Early to late	Medium	Medium	71	50	50	50	55	63
Grand fir	2,667	Early to late	Low	Medium	44	50	0	50	36	35
Lodgepole pine	4,673	Early	Medium	High	79	0	50	0	32	29
Mountain hemlock	4,658	Early to late	Medium	Low	78	50	50	100	70	85
Noble fir	3,831	Early	Medium	Low	64	0	50	100	54	61
Oregon white oak	1,014	Early	Medium	High	15	0	50	0	16	6
Pacific silver fir	4,180	Late	Medium	Low	70	100	50	100	80	100
Ponderosa pine	2,952	Early	Medium	High	49	0	50	0	25	18
Red alder	1,142	Early	Medium	Low	17	0	50	100	42	43
Shore pine	133	Early	Medium	High	0	0	50	0	13	0
Sitka spruce	691	Early to late	Medium	Low	10	50	50	100	52	59
Subalpine fir	4,986	Early to late	Medium	Medium	84	50	50	50	59	68
Sugar pine	2,900	Early to late	Medium	Medium	48	50	50	50	49	55
Western hemlock	2,110	Early to late	Low	Low	34	50	0	100	46	50
Western larch	4,050	Early	Medium	Medium	68	0	50	50	42	44
Western redcedar	1,971	Early to late	Low	Medium	32	50	0	50	33	30
Western white pine	4,276	Early to late	Medium	Medium	72	50	50	50	55	64
Whitebark pine	5,900	Early	High	High	100	0	100	0	50	56

Northwest Oregon subregion

SCORE CALCULATION

Risk Factor Scores



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OVERALL SUBREGION SCORES

Overall Score						
Tree species	Risk Factor Scores (automatically copied from the 5 factor sheets)					Final score
	Distribution	Reproductive capacity	Habitat affinity	Adaptive genetic variation	Insects and diseases	
Subalpine fir	77	75	68	67	100	77
Whitebark pine	100	100	56	0	82	67
Pacific silver fir	58	75	100	33	64	66
Mountain hemlock	69	50	85	33	64	60
Noble fir	67	75	61	33	64	60
Alaska yellow-cedar	91	75	64	67	0	59
Sugar pine	90	50	55	33	70	59
Grand fir	53	75	35	67	64	59
Lodgepole pine	78	25	29	67	82	56
Engelmann spruce	86	75	63	0	52	55
Oregon white oak	54	100	6	100	9	54
Western larch	98	0	44	67	52	52
Western hemlock	36	50	50	67	58	52
Bigleaf maple	50	25	43	100	33	50
Ponderosa pine	55	0	18	67	88	46
Douglas-fir	0	0	30	100	76	41
Western white pine	85	0	64	0	45	39
Sitka spruce	76	25	59	0	33	39
Red alder	39	0	43	67	42	38
Western redcedar	57	50	30	33	9	36
Black cottonwood	61	0	46	0	27	27
Shore pine	63	0	0	0	21	17

Northwest Oregon subregion

Table 15. Overall vulnerability scores for a forest tree climate change vulnerability assessment of six subregional study areas in the Pacific Northwest¹

Species	Subregional study area						Overall regional score
	W. WA	NW OR	E. WA	E. OR	Central OR	SW OR	
Whitebark pine		67	74	74	78	67	72
Subalpine fir	71	77	64	70	69	69	70
Pacific silverfir	81	66	62		59	56	65
Engelmann spruce	66	55	57	61	61	72	62
Subalpine larch			60				60
Noble fir	61	60	54				58
Grand fir	54	59	60				58
Port-Orford-cedar						56	56
Oregon white oak		54	62			48	55
Alaska yellow-cedar	51	59	50				53
Grand fir-white fir				51	47	55	51
Quaking aspen			44	57			51
Mountain hemlock	51	60	50		41	49	50
Sugar pine		59			51	39	50
Noble fir - Shasta red fir					48	48	48
Pacific madrone						46	46
Tanoak						46	46
Lodgepole pine, Sierra lodgepole pine		56	51	43	36	42	46
California black oak						45	45
Western hemlock	22	52	44		52	42	42
Douglas-fir	31	41	45	42	60	36	42
Bigleaf maple	29	50	47			39	41
Western larch		52	38	32	43		41
Canyon live oak						40	40
Jeffrey pine						39	39
Western white pine	38	39	28	57	33	36	38
Ponderosa pine		46	39	22	32	46	37
Incense-cedar					38	33	36
Western redcedar	26	36	45			35	36
Paper birch			35				35
Sitka spruce	26	39					33
Red alder	20	38				33	30
Knobcone pine						30	30
Black cottonwood	28	27	28	32			29
Western juniper				30	27		28
Shore pine		17					17

Lowest vulnerability Highest vulnerability

¹ Scores range from 0 to 100 (100 = highest vulnerability rating) within each subregion; average scores across all subregions are also presented. Analysis was performed on group 1 species; blank cells indicate that a species was either in group 2 or 3 or was absent from the subregion.

RESULTS

OVERALL VULNERABILITY SCORES



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Table 15. Overall vulnerability scores for a forest tree climate change vulnerability assessment of six subregional study areas in the Pacific Northwest¹

Species	Subregional study area						Overall regional score
	W.WA	MW/OR	E.WA	E.OR	Central OR	SW/OR	
Whitebark pine		67	74	74	78	67	72
Subalpine fir	71	77	64	70	69	69	70
Pacific silverfir	81	66	62		59	56	65
Engelmann spruce	66	55	57	61	61	72	62
Subalpine larch			60				60
Noble fir	61	60	54				58
Grand fir	54	59	60				58
Port-Orford-cedar						56	56
Oregon white oak		54	62			48	55
Alaska yellow-cedar	51	59	50				53
Grand fir-white fir				51	47	55	51
Quaking aspen			44	57			51
Mountain hemlock	51	60	50		41	49	50
Sugar pine		59			51	39	50
Noble fir - Shasta red fir					48	48	48
Pacific madrone						46	46
Tanoak						46	46
Lodgepole pine, Sierra lodgepole pine		56	51	43	36	42	46
California black oak						45	45
Western hemlock	22	52	44		52	42	42
Douglas-fir	31	41	45	42	60	36	42
Bigleaf maple	29	50	47			39	41
Western larch		52	38	32	43		41
Canyon live oak						40	40
Jeffrey pine						39	39
Western white pine	38	39	28	57	33	36	38
Ponderosa pine		46	39	22	32	46	37
Incense-cedar					38	33	36
Western redcedar	26	36	45			35	36
Paper birch			35				35
Sitka spruce	26	39					33
Red alder	20	38				33	30
Knobcone pine						30	30
Black cottonwood	28	27	28	32			29
Western juniper				30	27		28
Shore pine		17					17

RESULTS

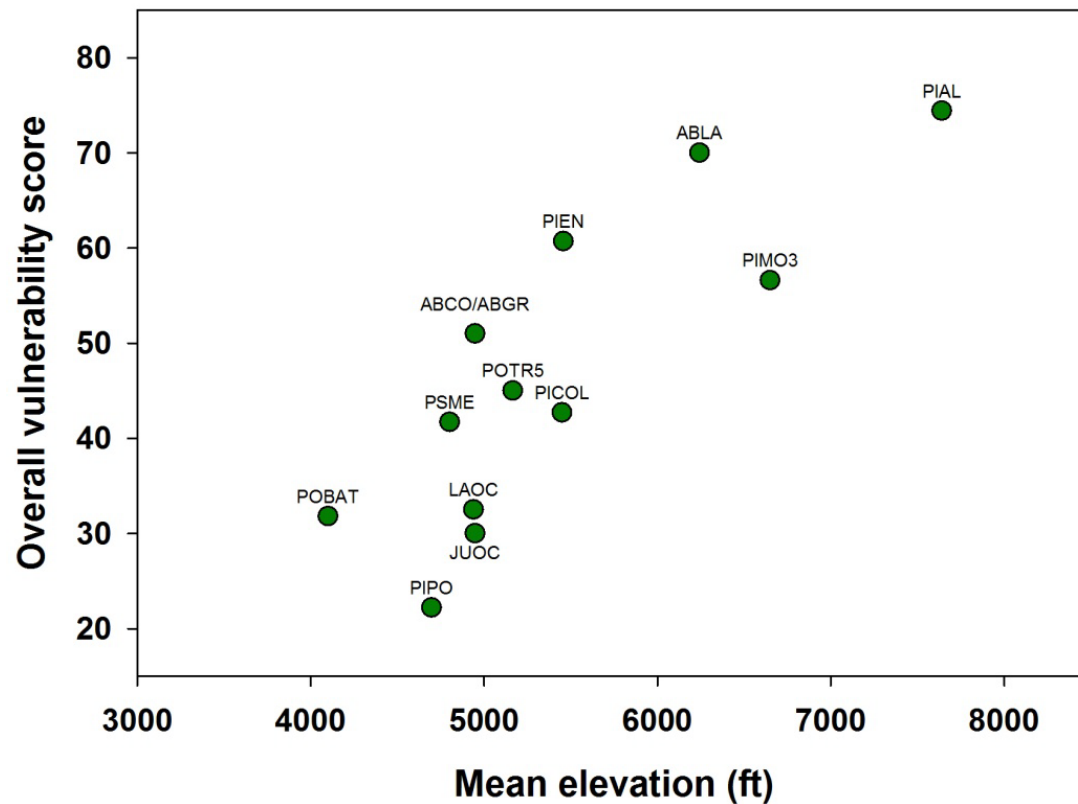
OVERALL VULNERABILITY SCORES



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VULNERABILITY ASSESSMENT RESULTS



Trend in increasing vulnerability with increasing mean elevation

- But not sensitive to the elevation variable



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VULNERABILITY AND ELEVATION

- Species limited to high elevation had limited distributions
- Many high-elevation species had relatively low values for fecundity and seed dispersal distance but high minimum seed bearing age (slower growth)
- Precipitation higher at high elevations and many high-elevation species have low drought tolerance
- Disjunct populations in several subregions increased adaptive genetic variation vulnerability score for whitebark pine and other species



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RECOMMENDATIONS AND MANAGEMENT ACTION ITEMS

Three themes:

1. Learn about and track changes in plant communities as the climate changes
2. Maintain and increase biodiversity and increase resilience
3. Prepare for the future



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RECOMMENDED ACTION ITEMS

- Monitoring
 - Phenology and growth
- Vegetation management options
 - Thinning and planting
 - Seed zones & seed movement
- Gene conservation
 - *In situ*
 - *Ex situ*



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