Forest Management with Resilience in Mind

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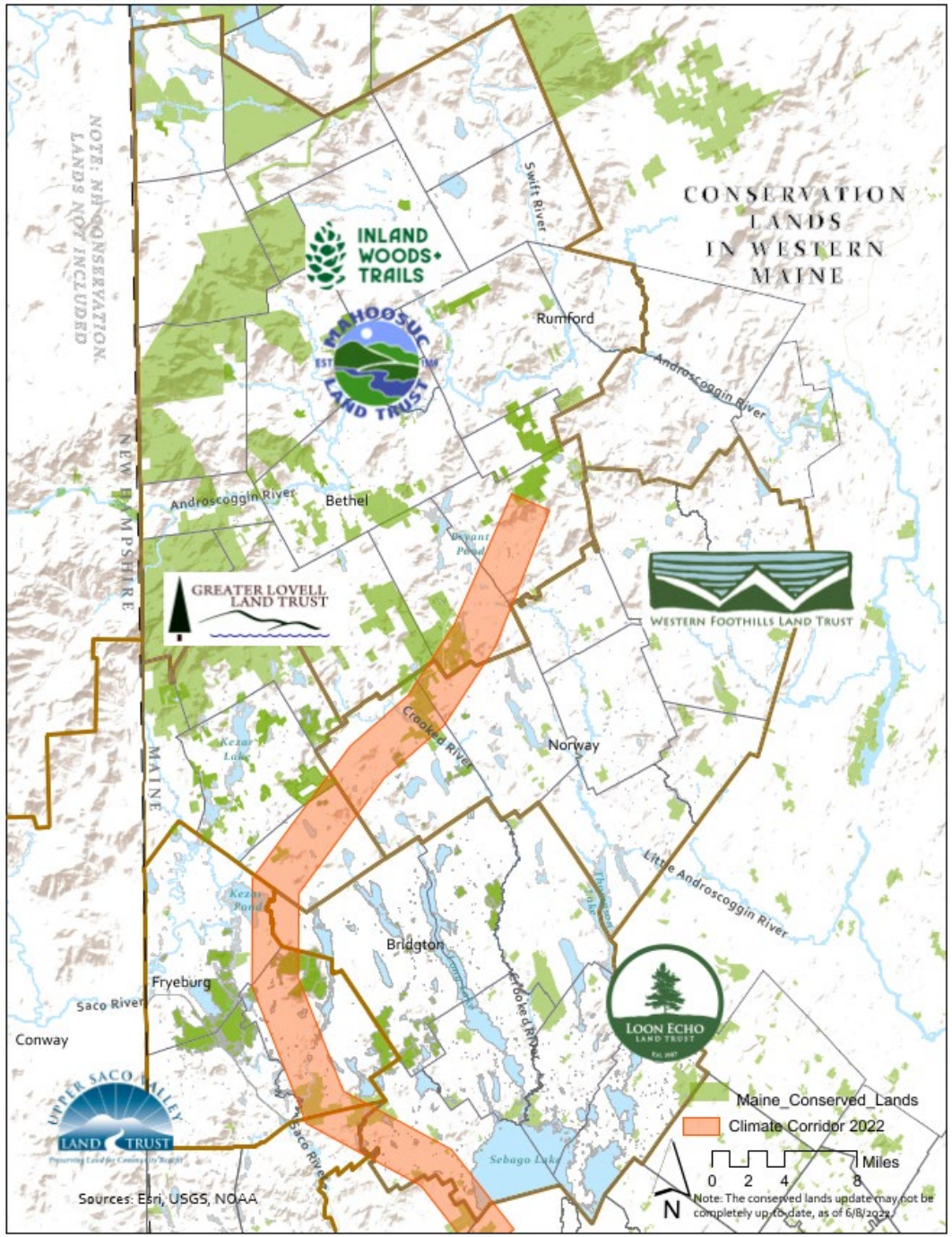
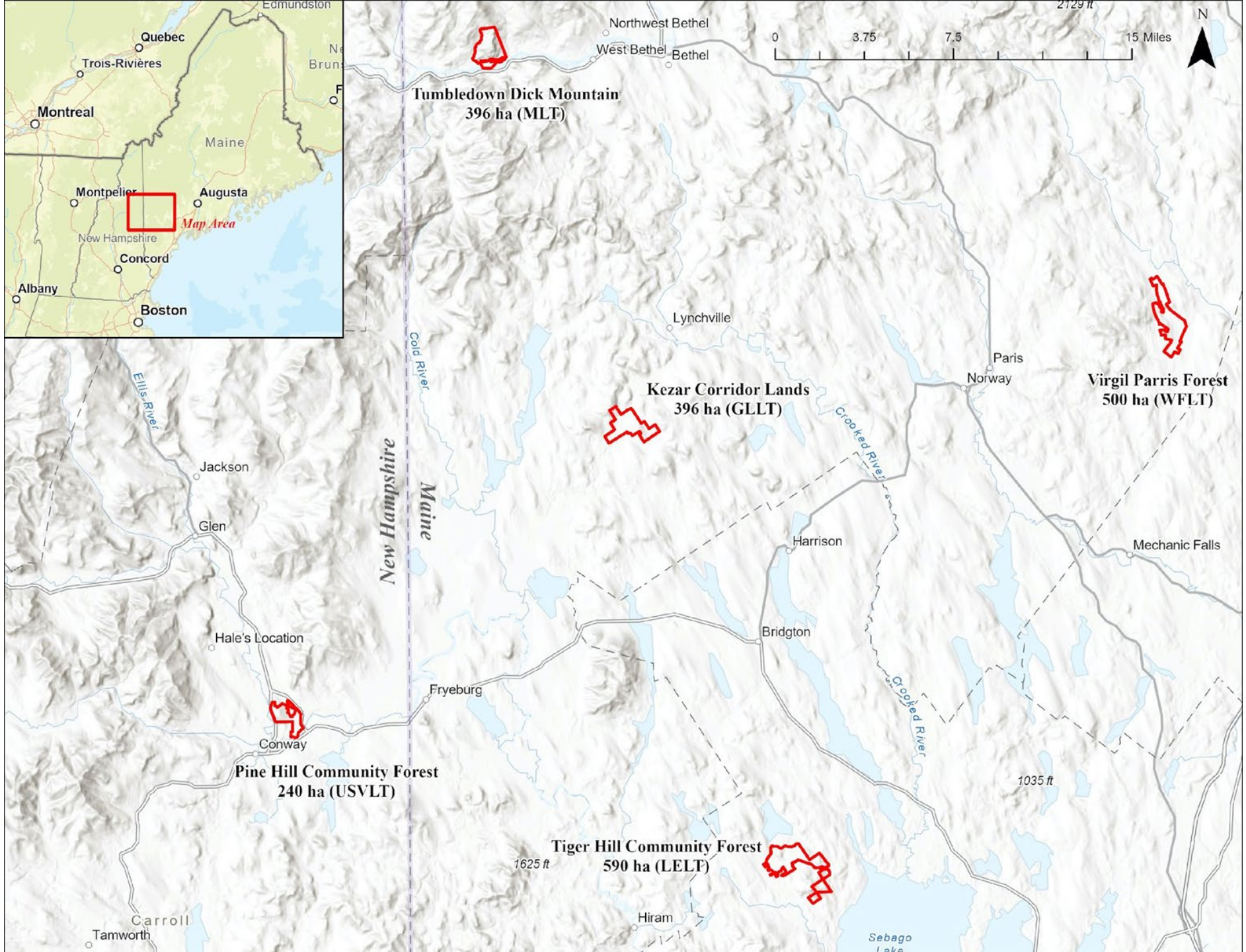
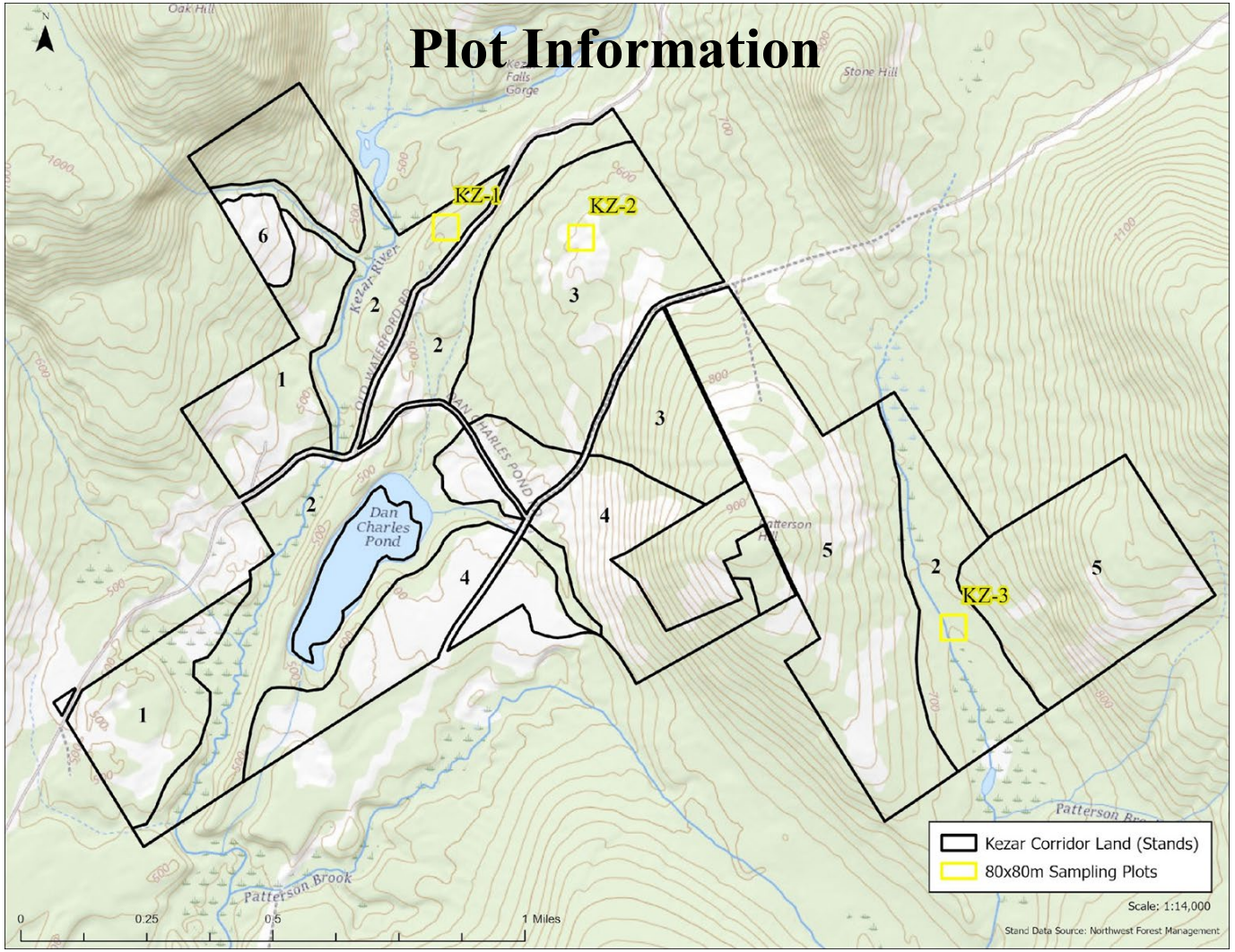
Will Durkin


Madawaska
St John River
Fort Kent
Van Buren
Caribou
Fort Fairfield
Presque Isle
Ashland
Mars Hill
Allagash River
APPALACHIAN MTNS
Chamberlain Lake
Chesuncook Lake
Houlton
Mt Katahdin + 5267
Millinocket
95
Jackman
Moosehead Lake
Macwahoc
Vanceboro
Greenville
Lincoln
Topsfield
Kennebec River
Penobscot River
Dover-Foxcroft
Flagstaff Lake
Calais
Dexter
Eastport
Newport
Orono
Bangor
Skowhegan
Machias
Farmington
Rumford
Waterville
Bucksport
Ellsworth
Belfast
Augusta
Bar Harbor
Norway
Camden
Mt Desert Island
Auburn
Lewiston
Rockland
Penobscot Bay
Gulf of Maine
Sebago Lake
Brunswick
Bath
Westbrook
Portland
Sanford
Saco
Biddeford
95
Kittery
ATLANTIC OCEAN

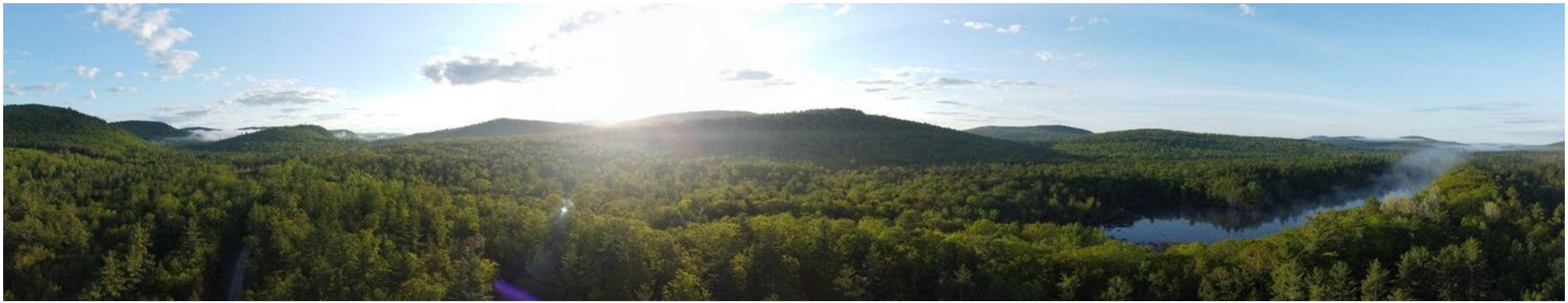

CONSERVATION LANDS IN WESTERN MAINE
NOTE: NH CONSERVATION LANDS NOT INCLUDED
INLAND WOODS + TRAILS
MAHOOSUC LAND TRUST
GREATER LOVELL LAND TRUST
WESTERN FOOTHILLS LAND TRUST
LOON ECHO LAND TRUST
UPPER SACO VALLEY LAND TRUST
Swift River
Rumford
Androscoggin River
Bethel
NEW HAMPSHIRE
MAINE
Crooked River
Norway
Little Androscoggin River
Bridgton
Fryeburg
Saco River
Conway
Sebago Lake
Maine_Conserved_Lands
Climate Corridor 2022
Miles
0 2 4 8
N
Sources: Esri, USGS, NOAA
Note: The conserved lands update may not be completely up-to-date, as of 6/8/2022


Quebec
Trois-Rivières
Montreal
Maine
Montpelier
Augusta
Map Area
New Hampshire
Concord
Albany
Boston
Edmundston
Northwest Bethel
West Bethel
Bethel
0
3.75
7.5
15 Miles
N
2129 ft
Tumbledown Dick Mountain
396 ha (MLT)
Lynchville
Paris
Norway
Virgil Parris Forest
500 ha (WFLT)
Kezar Corridor Lands
396 ha (GLLT)
Cold River
Ellis River
Crooked River
New Hampshire
Maine
Jackson
Glen
Harrison
Mechanic Falls
Hale's Location
Bridgton
Fryeburg
Conway
Pine Hill Community Forest
240 ha (USVLT)
Crooked River
1035 ft
Tiger Hill Community Forest
590 ha (LELT)
1625 ft
Carroll
Tamworth
Hiram
Sebago

Plot Information



Plot Name	Centroid Coordinates	Current Forest Type	Soil Map Unit (Symbol)	ESD Soil Type	Terrestrial Habitat Type (TNC)
KZ-1	44.191, -70.823	Pine-Hardwood	Colton (CHC)	Dry Sand	Appalachian (Hemlock)-Northern Hardwood
KZ-2	44.191, -70.817	Oak-Hardwood	Hermon (HVC)	Dry Sand	Appalachian (Hemlock)-Northern Hardwood
KZ-3	44.180, -70.802	Hemlock-Hardwood	Skerry (STC)	Loamy Slope	Laurentian-Acadian Pine-Hemlock-Hardwood



Climate Change Impacts

For this project, the most important anticipated climate change impacts include:

- Temperatures in New England are projected to increase 5.3 to 9.1 °F by late century (2071-2100), with the greatest warming expected to occur during winter.
- Winter will be shorter and milder, with less precipitation falling as snow and reduced snow cover and depth.
- The timing and amount of stream flow is expected to change over the next century across the region including more high streamflow days in winter and spring and low streamflow days in summer and fall.
- Forest vegetation in the region may face increased risk of moisture deficit and drought during the growing season.
- Warmer temperatures and altered precipitation in the region will interact to change soil moisture patterns throughout the year, with the potential for both wetter and drier conditions depending on the location and season.
- Certain insect pests and pathogens may increase in occurrence or become more damaging in the region (e.g., spongy moth, oak wilt, hemlock wooly adelgid).
- Many invasive plants will increase in extent or abundance in the region.
- Many northern and boreal tree species will face increasing stress across much of the region.

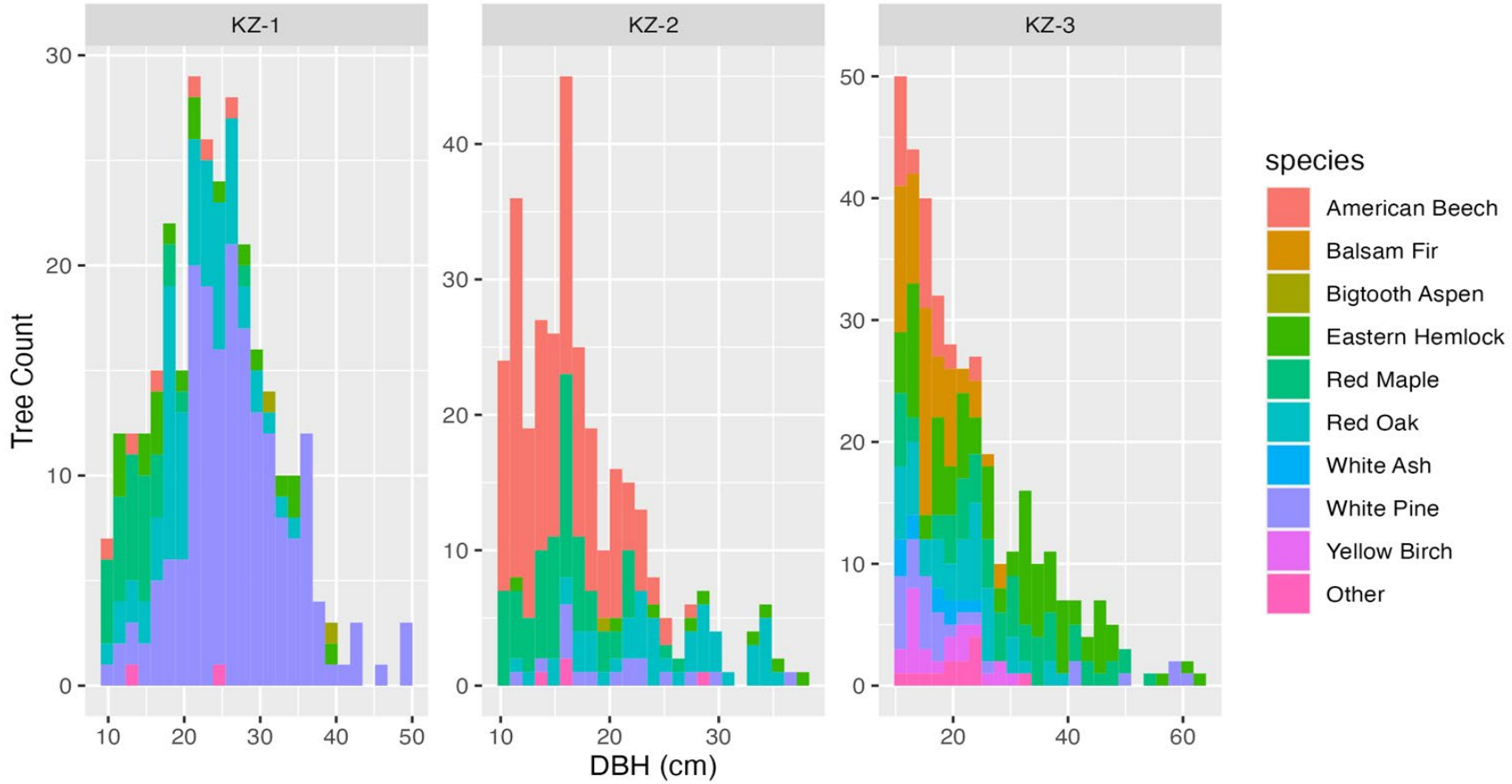
Management Goals

Improve and maintain the species and structural diversity of stands 2 and 3 on the property (15 years).

- Implement treatments to improve or maintain structural diversity.
- Implement treatments to improve or maintain species diversity.
- Monitor for infestations of invasive forest pests and nonnative plant species and implement treatments to control or remove infestations.

Area/Topic	Approach	Tactics
Stand 2	**2.2. Prevent the introduction and establishment of invasive plant species and remove existing invasive species.**	■ Conduct annual monitoring for invasive plant species along the river. This will be done by GLLT staff and volunteers as part of routine annual monitoring.
	1.3. Maintain or restore riparian areas. **9.2. Establish or encourage new mixes of native species.**	■ Reduce hemlock cover in favor of white pine (start in 1-5 years).
Stand 3	**5.1. Promote diverse age classes.**	■ Conduct a timber stand improvement/harvest or crop tree release to increase age class diversity in the stand.
	5.2. Maintain and restore diversity of native species.	■ Thin hardwood species and plant white pine to facilitate mixedwood species composition.
	5.3. Retain biological legacies.	■ Retain a certain number of legacy trees per species as seed sources, with particular focus on mast species (red and white oak), white pine, and eastern hemlock.

Initial Inventory Summary



Plot Name	Stems Measured	QMD (cm)	BA (m^2/ha)	Biomass (MgC)	Highest IV	Species Richness	Shannon's Diversity (H')	Functional Evenness	Functional Divergence	Functional Dispersion	Drought Tolerance (z-score)	Flood Tolerance (z-score)
KZ-1	301	25.4	23.8	151.2	White pine	7	1.02	0.38	0.88	2.72	-0.43	-0.95
KZ-2	322	18.6	13.7	206.4	American beech	8	1.39	0.39	0.88	2.96	-0.81	-0.24
KZ-3	366	25.2	28.5	225.2	Eastern hemlock	13	1.77	0.55	0.93	4.14	-1.30	0.15

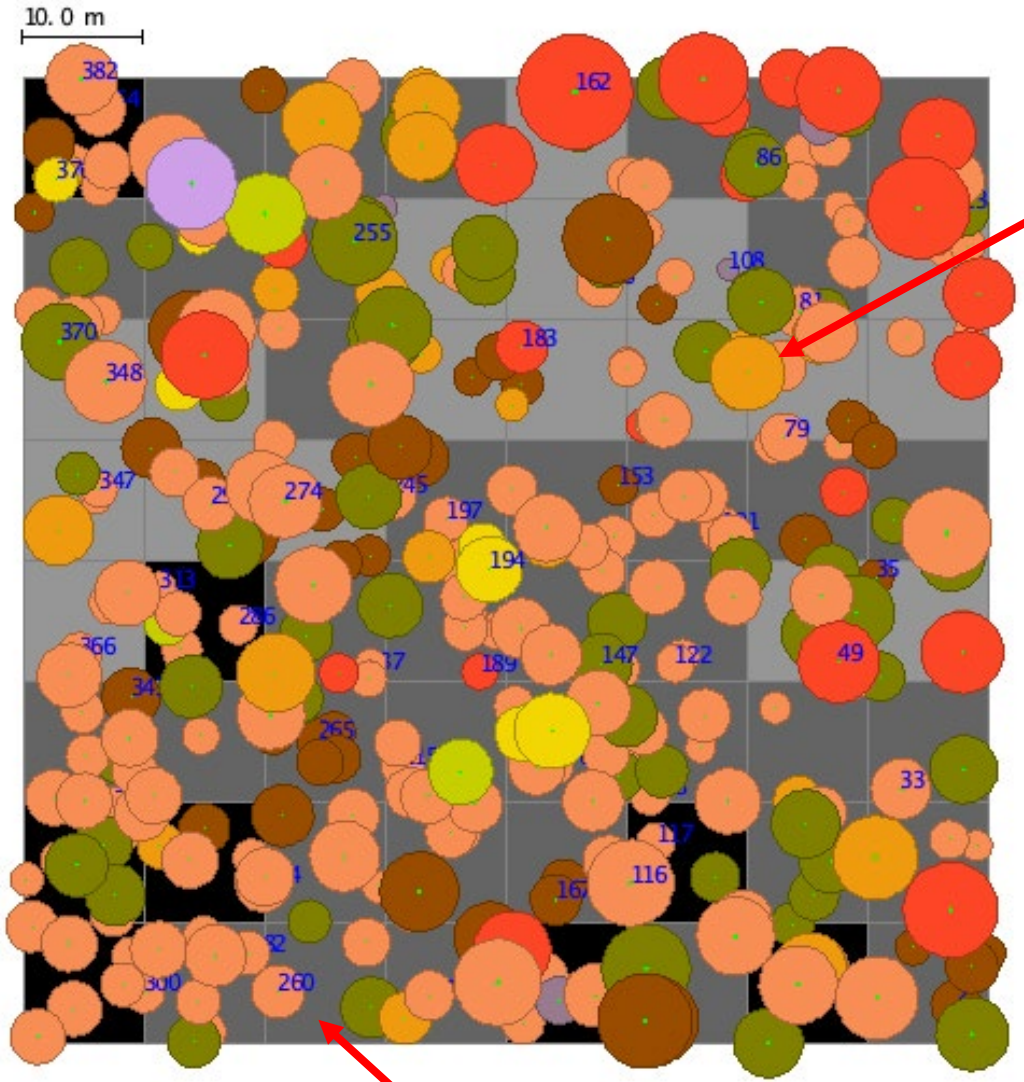
Management Scenarios

Site Name	Resilience Management	Transitional Management
KZ-1	**Variable Density Thinning** Simulation harvest years: 2043, 2063, 2083 - 70% of stand "Matrix": Thinning from below to 70% of basal area at each entry - 15% of stand "Skips": Areas of no management - 15% of stand "Gaps": Areas of complete overstory and regeneration removal with soil scarification - Gaps approx. 0.4 ha (1-acre))	**Expanding Gap Irregular Shelterwood** Simulation harvest entries: 2043, 2063, 2083 - Gap creation, 0.4 ha (1-acre) - Complete overstory and regeneration removal with soil scarification - Enrichment of Red Oak, White Oak - No thinning in matrix
KZ-2	**Variable Density Thinning** Simulation harvest entries: 2043, 2063, 2083 - 70% of stand "Matrix": Thinning from below to 70% of basal area at each entry - 15% of stand "Skips": Areas of no management - 15% of stand "Gaps": Areas of complete overstory and regeneration removal with soil scarification - Gaps approx. 0.4 ha (1-acre)	**Expanding Gap Irregular Shelterwood** Simulation harvest entries: 2043, 2063, 2083 - Gap creation, 0.6 ha (1.5-acre) - Complete overstory and regeneration removal with soil scarification - Enrichment of Red Oak, White Oak - No thinning in matrix
KZ-3	**Singe-tree/Group selection** Simulation harvest entries: 2023, 2043, 2063, 2083 - Removal of singe and groups of mature trees in overstory - Approx. 0.1 ha to 0.2 ha (0.25 to 0.5-acre) canopy openings - Single-tree/Groups in 30% of stand area - No thinning outside of groups/matrix	**Continuous Cover Irregular Shelterwood** Simulation harvest entries: 2023, 2043, 2063, 2083 - Group selection, 0.2 ha (0.25 to 0.5-acre) canopy openings - Groups in 30% of stand area - Thinning from below outside of groups/matrix to 70% of basal area - Enrichment of Basswood, Bitternut Hickory, Black Walnut

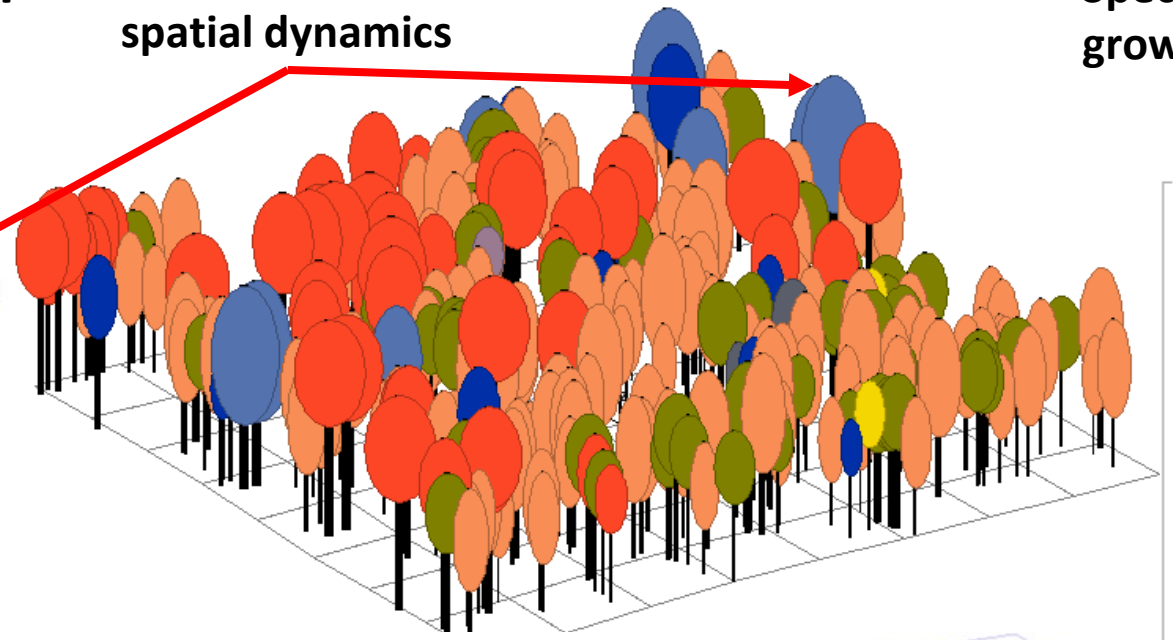
HETEROFOR: Forest Growth Model

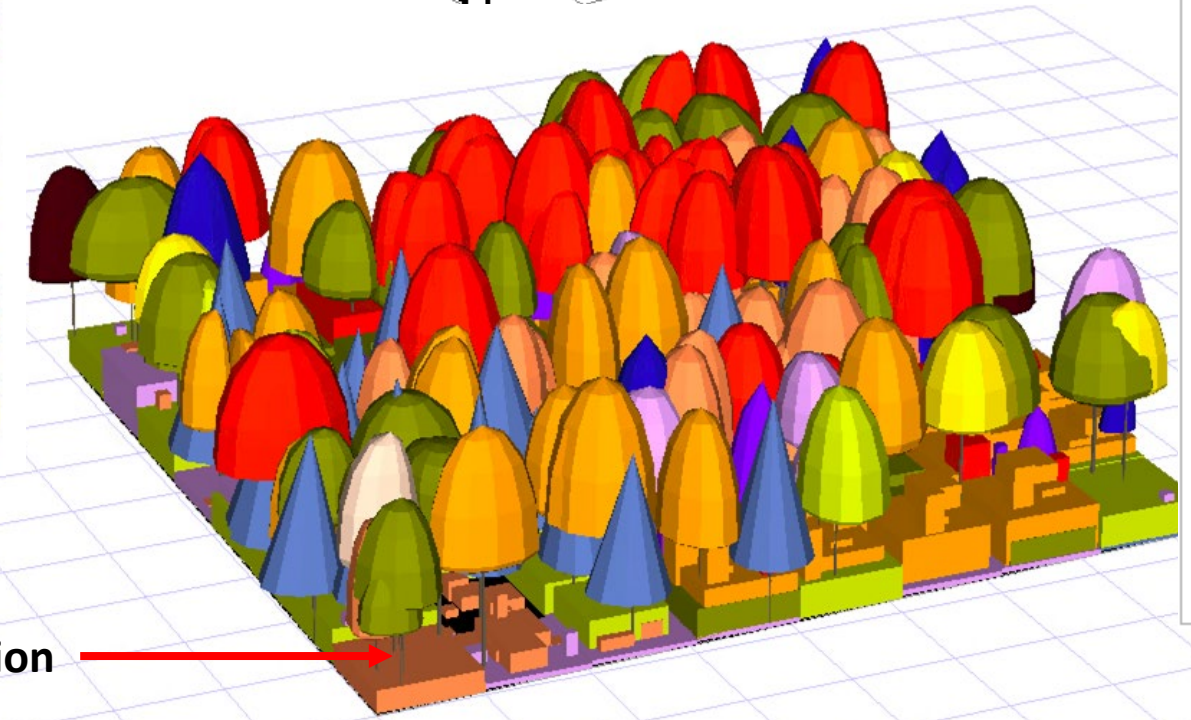
Simulates stand spatial dynamics

Species-specific growth parameters



Accounts for light conditions





Regeneration


Air Temperature (°C)
22
18
14
10
Precipitation (mm/year)
1750
1500
1250
1000
750
Atmospheric CO2 (ppm)
1000
800
600
400
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
2065
2070
2075
2080
2085
2090
2095
2100
Year
SSP5-8.5
SSP2-4.5

Under Climate SSP2-4.5

Management	Year	Red maple	Paper birch	Beech	White pine	Bigtooth aspen	White oak	Red oak	Hemlock	Red spruce
Initial	**2023**	14%	<1%	38%	5%	<1%		36%	6%	1%
No Management	**2060**	10%	<1%	46%	3%	<1%		38%	3%	<1%
	2100	10%	<1%	72%	1%	<1%		15%	1%	
Resilience	**2060**	8%	<1%	45%	2%	<1%		42%	2%	<1%
	2100	12%	<1%	70%	1%	<1%		15%	1%	<1%
Transition	**2060**	9%	<1%	45%	3%	<1%		39%	3%	<1%
	2100	10%		14%			17%	58%	1%	

Under Climate SSP5-8.5

Management	Year	Red maple	Paper birch	Beech	White pine	Bigtooth aspen	White oak	Red oak	Hemlock	Red Spruce
Initial	**2023**	14%	<1%	38%	5%	<1%		36%	6%	1%
No Management	**2060**	10%	<1%	46%	2%	<1%		39%	2%	<1%
	2100	9%	<1%	73%	<1%	<1%		15%	1%	<1%
Resilience	**2060**	7%	<1%	47%	1%	<1%		42%	2%	<1%
	2100	10%	<1%	67%	<1%	1%		21%	1%	<1%
Transition	**2060**	10%	<1%	44%	4%	<1%		39%	3%	<1%
	2100	9%		11%			18%	61%	1%	

Change in Diversity Indices (2023 to 2100)

Management	Climate	Shannon's Diversity (H')	FEve	FDiv	FDis	Drought Tolerance (z-score)	Flood Tolerance (z-score)
Initial	--	*1.39*	*0.39*	*0.88*	*2.96*	*-0.81*	*-0.24*
No Management	SSP2-4.5	-0.50	0.02	-0.21	-1.11	-0.47	0.09
	SSP5-8.5	-0.53	0.12	-0.03	-1.18	-0.46	0.07
Resilience	SSP2-4.5	-0.48	-0.09	**-0.02**	-0.97	-0.45	**0.15**
	SSP5-8.5	-0.44	**0.14**	**-0.02**	-0.95	-0.32	0.05
Transitional	SSP2-4.5	**-0.21**	0.10	-0.16	**-0.82**	0.87	-0.22
	SSP5-8.5	-0.26	0.07	-0.14	-0.97	**0.95**	-0.27

Key Takeaways:

- Overall decline in species and functional trait indices

- Transitional Management: Higher species diversity (Shannon's), greater variability and representation in functional traits (FDis) than No Management and Resilience. Much greater drought tolerance

- **Resilience Management:** Greater even distribution of functional traits (FEve) and higher abundance of specialized traits (FDiv). Greater flood tolerance

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