Ecological System	Floodplain Forest				Wet Forest					Forested Rich Peatland								Acid Peatland	
Floristic Region	Northern		Southern		Northern			NW	SO	Northern						NW	SO	Northern	
NPC Class	FFn57	FFn67	FFs59	FFs68	WFn53	WFn55	WFn64	WFw54	WFs57	FPn62	FPn63	FPn71	FPn72	FPn81	FPn82	FPw63	FPs63	APn80	APn81
Quaking aspen	-				9d	2d	3d	1d									-		
Jack pine																			
Red pine																			
White pine						12d				-			-		-				3wd
White spruce	-				6d	15d	-	4		-			-				5d		
Northern pin oak																			
Black cherry																			
Red cedar																			
Black oak																			
Shagbark hickory																			
Basswood	3wd		6d			10wd			2wd										
Paper birch	8d				3d	8d	7d	6d	5d	3wd	5wd		3wd				3d		-
Sugar maple			13d			-			3wd										
Northern red oak									-										
Red maple						6wd	6wd										-		
Bur oak	5wd	6wd	14d			14wd			8wd										
Ironwood																			
Big-toothed aspen																			
White oak									-										
Bitternut hickory			12w																
Butternut																			
Silver maple	1w	1w	1w	1w															
American elm	6w	4wd	2w	4wd		11wd	8wd	8w	6w				-						
Green ash	4w	2wd	9w	2wd		5wd			7w										
Box elder	7w	5wd	4w	6wd					10w										
Red elm			11w				10wd		9w										
Hackberry			7w	8wd															
Cottonwood			3w	3w															
Black walnut			10w																
Swamp white oak			5w	7wd															
River birch				5d															
Rock elm			15w																
White cedar					1	4	4			4	1	3d			3d				
Balsam fir	9				4d	9d	9d	5		5d	3d						4d		
Balsam poplar					7d	7d		2											
Black ash	2	3	8		2w	1w	1w	3w	1				-			-			
Yellow birch					8wd	3wd	5wd		4										
Tamarack					-	-	2	7		2	4	2	1	1	1	1	1	2	2
Black spruce					5	13				1	2	1d	2	2d	2d	2	2	1d	1d

Suitability of Tree Species by Native Plant Community (NPC)

Purpose

These tables are intended to help foresters decide which tree species to silviculturally favor or introduce on sites that have been classified using the *Field Guides to the Native Plant Communities of Minnesota*[1]. Trees with excellent suitability should grow well with very little silvicultural treatment other than providing the correct light and seedbed environments for establishment and recruitment. Trees with poorer suitability for a site can be grown to meet specific objectives, but the forester should expect progressive increases in cost and risk for trees with good to fair to poor suitability rankings. The underlying assumption for using these tables is that when trees are naturally suited to their site, they are vigorous. Vigor should translate to superior quality, resistance to disease, capacity for natural regeneration, and the ability to withstand fluctuations in climate.

Suitability Index

Suitability is a mathematical calculation. The data for this calculation come from 4,414 vegetation plots that have been classified as belonging to one of 52 forested NPCs. Two metrics -- commonness and local abundance -- are the elements of suitability.

A plant is "suited" to a NPC when we often find it there. Percent presence was our metric of commonness. Similarly, a plant is "suited" to a NPC when it tends to occur in abundance when present. Mean percent cover-when-present was our metric of local abundance. ***The suitability index is the product of percent presence and mean percent cover-when-present***.

Example: Of the 4,414 sample plots, 256 were classified as Northern Mesic Hardwood Forest (MHn35). Basswood trees occur in 164 of the 256 plots. Thus, its percent presence as a tree is (164/256)*100= 64.1%. The mean cover of basswood trees on those 164 plots is 15.0%. Thus, its suitability index is 64.1*15.0=962.

Climate Shift Calculations

Due to global warming, land managers are bracing for local vegetation shifts to plants whose North American ranges are warmer and drier than their habitat in Minnesota[2]. An analysis of range climate was used to assign[3] and adjust[4] "synecological" scores for our plants with regard to moisture (M) and temperature (H). The scores range from 1 (dry/cool) to 5 (wet/warm). The difference between a plant's individual synecological score and the mean synecological score of its community provides some insight as to whether that plant would benefit or or suffer should its local environment become warmer or drier.

Example: For each of the 256 MHn35 vegetation plots, the M score of all component plants was summed and averaged to yield a score for each plot. Then the plot scores were summed and averaged to yield an M score for the community, which in this case was 2.3. The adjusted M score for basswood is 2.01, which is drier than 2.3. Thus, we assume that basswood would benefit from a slightly drier conditions. Similarly, the H score for basswood is 4.03, which is substantially warmer than the 2.9 mean for the MHn35 community ... suggesting that basswood would greatly benfit if MHn35 sites get warmer.

Using the Tables

What the Colors Mean -- trees compared to all plants

Cell colors indicate whether a tree would be an excellent, good, fair, poor, or very poor choice as a crop tree. A tree's assignment to one of these classes was based upon its suitability index when compared to the index of all other common plants in that community.

Example: For the MHn35 community, there were 113 plants with >5% presence. The suitability index of each plant was placed in a table and the table sorted to rank plants by their index. The ranking was segregated into 4 groups of 23 plants each and a final class of 21 plants. The group of 23 plants with the highest indices were assigned excellent suitability, the next 23 plants were assigned good suitability, etc. Basswood had the 8th highest ranking, placing it in the excellent class along with 22 other plants.

What the Numbers Mean -- trees compared to other trees

The cell numbers indicate a tree's suitability index ranking as compared to all other trees. A tree with the number 1 is considered the tree most suited to that NPC.

Example: For the MHn35 community, sugar maple trees had the second highest ranking overall and the highest ranking among all trees, so a 1 appears in the cell. Basswood had the eighth overall ranking, which was the second highest ranked tree, so a 2 appears in the cell.

What the Letters Mean -- tree affinity for warmer or drier site conditions

For each tree the a lower-case "w" follows the tree ranking when that tree has a warmer synecological score than the average for the community. A lower-case "d" follows the the tree ranking if it has a drier synecological score than the community mean.

Example from MHn44 Community		
Quaking aspen	1d	excellent rating; 1st ranked; favored if habitat gets drier, disfavored if warmer
White cedar	7	good rating; 7th ranked; disfavored if habitat gets warmer and/or drier
Sugar maple	13wd	fair rating; 13th ranked; favored if habitat gets warmer and/or drier
Green ash	14w	poor rating; 14th ranked; favored if habitat gets warmer, disfavored if drier
American elm	--	very poor rating; occurs in trace amounts; ranking and climate shift not presented
Jack pine		not known to occur in MHn44, no calculations possible

1. **Minnesota Department of Natural Resources** (2003, 2005, 2005). Field Guide to the Native Plant Communities of Minnesota. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. MNDNR St. Paul, MN.
2. **Minnesota Department of Natural Resources** (2011). Climate Change and Renewable Energy: Management Foundations. Climate and Renewable Energy Steering Team. MNDNR St. Paul, ,MN.
3. **Bakuzis, E.V. and Kurmis, V.** 1978. Provisional list of synecological coordinates and selected ecographs of forest and other plant species in Minnesota. Staff Series Paper 5. Department of Forest Resources, University of Minnesota. St. Paul, MN, US.
4. **Brand, G.J., and Almendinger, J.C.** 1992. Synecological coordinates as indicators of variation in red pine productivity among TWINSPAN classes: A case Study. Research Paper NC-310. North Central Forest Experiment Station, U.S. Department of agriculture, St. Paul, MN.

Ecological Land Classification Program, Division of Forestry
Minnesota Department of Natural Resources
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Ecological System	Fire-dependent Forest																
Floristic Region	Northern					Northwestern			Central					Southern			
NPC Class	FDn12	FDn22	FDn32	FDn33	FDn43	FDw24	FDw34	FDw44	FDc12	FDc23	FDc24	FDc25	FDc34	FDs27	FDs36	FDs37	FDs38
Quaking aspen	3w	-	4wd	4d	3wd	2	1d	1d		4	2d	3	3d	10d	2d	6d	10d
Jack pine	1	2	1d	5d	10d	3	4d		1	1	1d	2	9d	9d			
Red pine	2d	1d	3d	1d	4d				2d	6d	3d	6d	1d				
White pine	-	3	5wd	3d	2wd								2d	2d			
White spruce	4		-	10	7		3	3									
Northern pin oak												1wd		1wd		1wd	2wd
Black cherry														12wd		10wd	5wd
Red cedar														14wd			
Black oak														3wd			7wd
Shagbark hickory																	3wd
Basswood													10wd	18wd	3wd		17d
Paper birch	-	4	6wd	2d	1wd					5	5d	4	5d	6d	7d	8d	16d
Sugar maple																	19d
Northern red oak		7w		11wd						2w	6wd	8w	4wd	4wd	4wd	3wd	6d
Red maple		6w	-	8wd	8wd							9w	6wd			5d	
Bur oak						1w	2wd	4wd		3w	4wd	7w	7wd	7wd	1wd	2wd	1d
Ironwood														8wd			12d
Big-toothed aspen		5wd		7wd						7wd		5wd	8wd	-		7d	15d
White oak														5wd		4wd	8wd
Bitternut hickory														16w			11w
Butternut																	-
White ash														15wd			
Silver maple																	
American elm								6w						13w	5w	11w	4w
Green ash								5w				-			6w	9w	
Box elder														19w		12w	13w
Red elm														-	-		18w
Hackberry																	14w
Cottonwood														17w			
Black walnut														11w			9w
Swamp white oak																	
River birch																	
Rock elm																	
White cedar					5												
Balsam fir	5		7	6	6												
Balsam popular						-	5	2									
Black ash																	
Yellow birch																	
Tamarack																	
Black spruce	-		2	9	9												

Ecological System	Mesic Hardwood															
Floristic Region	Northern					NW	Central					Southern				
NPC Class	MHn35	MHn44	MHn45	MHn46	MHn47	MHw36	MHc26	MHc36	MHc37	MHc38	MHc47	MHs37	MHs38	MHs39	MHs49
Quaking aspen	5d	1d	9d	3d	11d	3d	2d	5d	3d		8d		16d		
Jack pine															
Red pine		15d					10d								
White pine	9d	8d	10d				9d			2d		10d	8d		
White spruce	-	6	6	14											
Northern pin oak												3wd			
Black cherry												13wd	19wd	-	16wd
Red cedar															
Black oak															
Shagbark hickory												12wd			
Basswood	2wd	5wd	5wd	2wd	2wd	1wd	5wd	3wd	2wd	8wd	1wd	4d	3d	2d	1d
Paper birch	4d	4d	3d	7d	4d	-	3d	8d	5d	5d	9d	11d	11d		
Sugar maple	1wd	13wd	1wd	6wd	1wd		6wd	1wd	1wd	1wd	4wd	7d	2d	1d	2d
Northern red oak	3wd	11wd		9wd	5wd		1wd	2wd	4wd	3wd	5wd	1d	1d	3d	14d
Red maple	6wd	3wd	8wd	5wd	9d		4d	7d			6d				
Bur oak	10wd	12wd		4wd		2wd	7wd	4wd	6wd	-	3wd	6d	4d	10d	4d
Ironwood	8wd				7wd		13wd	14wd	7wd	7wd		9d	5d	6d	12d
Big-toothed aspen	7wd			15wd			8d	9d		-		14d	15d	12d	
White oak							11wd	11wd		9wd		2wd	7wd	11wd	
Bitternut hickory								10w		11w		16w	10w	7w	10w
Butternut								-			11w	-		14w	13w
White ash								12wd					14wd		
Silver maple															-
American elm		-		16w		4w		-	8w		10w	5w	9w	5w	5w
Green ash		14w		8w	10w	5w	12w	6w	9w	10w	7w	-	6w	9w	11w
Box elder												-	13w	13w	8w
Red elm								-				8w	17w	4w	6w
Hackberry												15w	12w	-	7w
Cottonwood						-									-
Black walnut												-			15w
Swamp white oak															
River birch															
Rock elm															9w
White cedar		7	4	11	8										
Balsam fir	12	2	7	12	-					6					
Balsam poplar		10		10		6									
Black ash		9w	-	1w	6			13		12	2	17	18	8	3
Yellow birch	11w		2w	13w	3					4					
Tamarack															
Black spruce															