Fire Regime Condition Class (FRCC) Interagency Handbook
Reference Conditions

Modeler: Dave Cleland, Jim Merzenich, Randy Swaty | **Date:** 6 January, 2005 | **PNVG Code:** GLSF

Potential Natural Vegetation Group: Great Lakes Spruce-Fir

Geographic Area: Areas in northern Minnesota with soils that are deeper or finer textured than soils in the jack pine forest that allowed development of dense forests of mixed aspen, birch, balsam fir, white spruce, and red maple (Frelich, 1998). This community occurred in upland positions, often with loamy shallow soils within bedrock controlled landforms (Heinselman 1996).

Description: The spruce-fir PNVG is composed of a mixture of balsam fir, white spruce, paper birch, black spruce, cedar, and quaking aspen (Heinselman 1996). In areas where the landscape has interspersed small wetlands, tamarack also was an important component of post-fire forests (Frelich 1998). Species dominance was determined by time since past disturbance, incidence of spruce budworm, neighborhood effects of seed source and dispersion (Frelich and Reich 1995), and associated successional dynamics.

Frelich (1998) stated, "These forests formed a successional system of aspen-paper birch, spruce, fir, and red maple. Fires were just as large as in the jack pine forest, but not as frequent (Heinselman 1981)." About 2/3 of all stands would be less than 100 years old, and a few stands (10-15%) would have survived 200 years or more before burning. Therefore, the landscape was a mosaic with young even-aged stands dominated by aspen and birch, middle-aged stands of mature birch and aspen with conifers in the understory, and some older stands almost completely dominated by conifers but with some red maple. Fire acted to set back succession." Frelich and Reich (1995) reported the lack of fire in near-boreal jack pine forest causes succession to a spruce-fir-birch- cedar mixture, and intense fire after heavy windfall can convert the forest to paper birch and aspen.

Almendinger and others (2003, Minnesota Department of Natural Resources) described successional trajectories within this community as having three growth stages separated by two transition periods. Initially young predominantly aspen stands with jack pine and birch dominated for the first 35 years following fire. Then during a transition period between 35 and 55 years following fire, aspen and jack pine declined and paper birch, white pine, red pine, and balsam fir increased, with establishment of white spruce seedlings occurs. Mature mixed forests composed of paper birch and white pine, with a reduced presence of balsam fir, establish and persist up to around 100 years. Another transition period marked by significant increase in white spruce and decline of aspen and birch occurs for a couple of decades. At around 115 years past fire stable long-lived white pine and white spruce dominated the canopy, with lesser amounts of balsam fir and paper birch present as subordinates.

In Canada's southeastern boreal forest, Bergeron et al. (1988) reported intolerant trembling aspen and white birch dominated the canopy during the first 100 years following stand-replacing fire. Stand breakup then occurred gradually, and a second cohort of hardwoods as well as shade-tolerant fir and white spruce recruited in the understory formed mixedwood stands. In contrast to the relatively rapid succession in Minnesota, only after 200 years, following mortality of the second and even third intolerant hardwood cohort, were stands dominated by softwood species in Canada's southeast boreal forest (Figure 1).

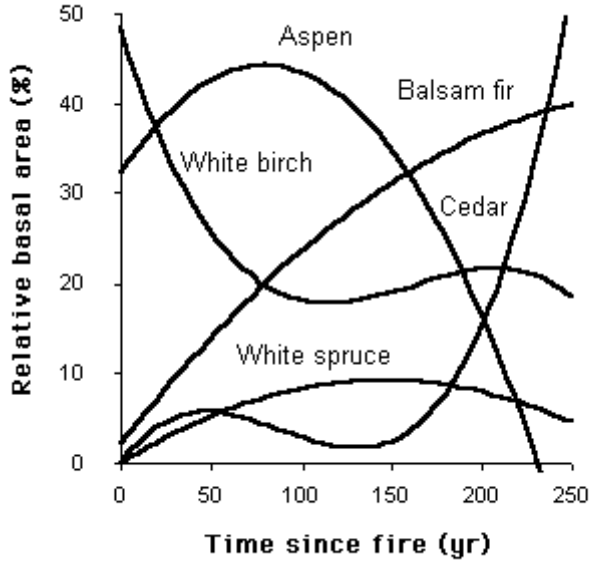

Figure 1. From Bergeron et al. 1988. "Proportion of different species as a function of time since the last fire. Data are from stands growing on mesic clays soils in Quebec's southwestern boreal forest."

Fire Regime Description: Fire regime group IV with fires occurring every 60 to 150 years and high stand replacement severity. Severe stand-replacing wind events affect mature stands on an approximate 1,000-year interval.

Arseneault (2001) reported "Stand-replacing wildfire is the most widespread disturbance in several coniferous boreal landscapes. These landscapes, which are characterized by a fire rotation period usually varying between 50 and 150 years (Heinselman 1981; Payette 1992), are frequently composed of pure or mixed, even-aged stands at different stages of recovery after fire."

Heinselman (1996) estimated rotations of stand-replacing crown fires for the spruce-fir PNVG at 70 to 110 years, and Swain (1973) estimated approximately 60 to 70 years. Cogbill (1985) reported a 130 year fire rotation for the spruce-feathermoss community in Canada, Larsen (1973) reported 78 years for black spruce dominated forests and 96 years for white spruce dominated forests, and Bergeron et al. (1998) reported 63 years for boreal mixedwoods. Mixed fires occurred in landscapes with higher proportions of early successional deciduous species, whereas in conifer-dominated areas severe crown fires killed all or most of structural layers.

Time since disturbance strongly influenced both succession and fire regime within this community. In the decades immediately following a fire, less flammable aspen and birch dominate (Figure 2). For boreal mixedwood forests of Canada, Cumming (2000) stated, "The probability of fires igniting in deciduous stands is extremely low, if not zero. If these stands burn, it must be from fires that started elsewhere." Fire probability often increased with stand age due to the general increase in fuel along the forest floor and development of fuel ladders. Fire probability also increased along a successional gradient due to higher proportions of conifers, particularly shade-tolerant short-lived balsam fir.

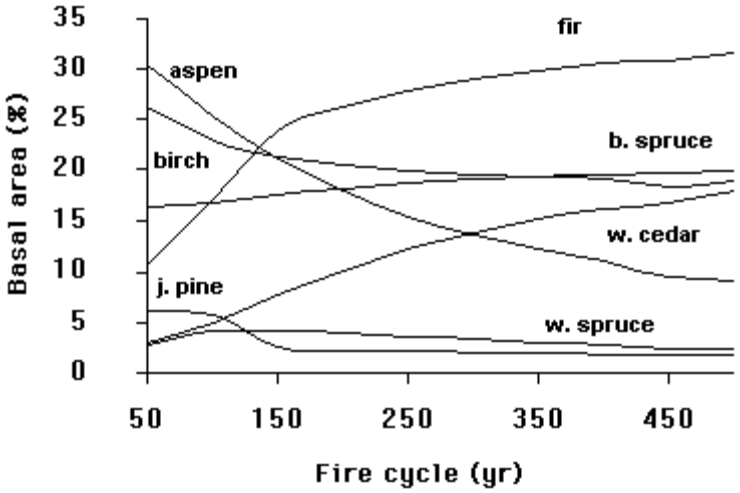

Figure 2. From Bergeron et al. 1998. "Estimated effect of fire cycle changes on the proportion of different species in a typical landscape from Quebec's southern boreal forest."

Fire regimes, gap formation, and succession within the spruce-fir PNVG were strongly influenced by spruce budworm infestations. The budworm infests white and black spruce and balsam fir, however mature balsam fir is far most susceptible to mortality following 3 to 4 years of successive defoliation.

In a study of a 15-year outbreak of the spruce budworm in a boreal mixedwood forest in Ontario, Canada, Nealis and Régnière (2004) reported that differences in susceptibility to injury and mortality are due to the degree of synchrony between spruce budworm phenology during the feeding stages and host-tree phenology. More rapid flushing and growth of current-year buds in white spruce and later flushing of current-year buds in black spruce reduced damage relative to that on balsam fir. They found that by the end of the outbreak, 89% of the balsam fir component >10 cm DBH was eliminated compared with 49% of the white spruce in the same size class. The lower susceptibility of black spruce resulted in survival of all but the smallest size classes of that species.

Boulanger and Arseneault (2004) reconstructed the history of eastern spruce budworm outbreaks over the last 450 years in southeastern Quebec. They found that outbreak frequency has remained quite stable, with a mean interval of about 40 years between the midpoints of successive outbreaks since the mid-16th century. Parent et al. (2001) reported a 30-year interval for outbreaks over the past century. Williams and Liebold (2000) reported population oscillations of 30 – 35 years in the eastern United States, which typically include 5 – 10 years at high outbreak levels.

Stocks (1985) reported forest fire potential in budworm-killed balsam fir significantly increased for a number of years following stand mortality due to crown breakage, wind throw, and increased surface fuel loadings that peaked 5-8 years after mortality. The principal effect was extending the potential for crown fires following green up into summer periods, which otherwise seldom experienced such fires. Fleming et al. (2002) reported that fires occurred 3–9 years after a spruce budworm outbreak disproportionately often. They noted "This `window of opportunity' for wildfire varies geographically: it starts later after SBW outbreak and lasts longer in western than in eastern Ontario. In addition, 7.5% of the areas containing SBW killed trees were burnt in western compared to 4.8% in eastern Ontario."

Vegetation Type and Structure

Class*	Percent of Landscape	Description
A: early-seral open	30	Early seral aspen/birch stands (0-40 yrs).
B: early-seral closed	35	Mid age stands with mature aspen/birch overstory and balsam fir, white spruce, and red maple understory (40-100 yrs).
C: mid-seral closed	25	Mid age stands dominated by white spruce and balsam fir (101-200 yrs). Spruce budworm generates excessive fuels following outbreaks every 40 years
D: late-seral closed	10	Old stands > 200 years.
Total	100	

*Formal codes for classes A-E are: AE1O, BE1C, CM1C, and DL1C, respectively.

All fires are stand-replacing and return the vegetation to aspen/birch. Replacement fire probabilities in conifer stands increase with age due to fuel buildup created by repeated spruce budworm attacks. Annual fire probabilities are assumed to be 0.8% in class B, and 1.2% in classes C and D. Aspen/birch stands burn on a 150-year rotation (0.67% per year). The disturbance probabilities by class applied in the model are contained in the VDDT documentation section.

Fire Severity	Fire Frequency (yrs)	Probability	Percent, All Fires	Description
Replacement Fire	110	.009	100	
Non-Replacement Fire	NA	NA	NA	
All Fire Frequency*	110	.016	100	

*All Fire Probability = sum of replacement fire and non-replacement fire probabilities. All Fire Frequency = inverse of all fire probability (previous calculation).

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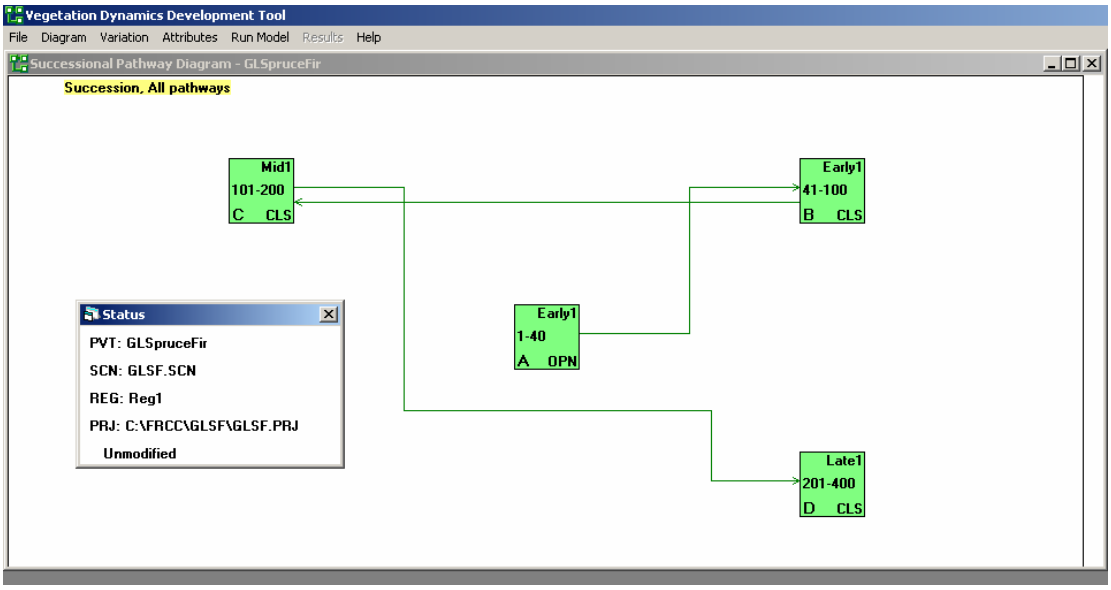
VDDT file documentation: Model is located in C:\FRCC\GLSF. Text files must be located in C:\FRCC for project file to work. Diagram shows succession only.



Disturbance probabilities by class: VDDT model GLSF

Class	To	Agent	Prob	TSD	Freq/ FRI	Rel Age
A	A	Replacement fire	.0067	0	150	-60
B	A	Replacement fire	.008	0	125	0
B	B	Wind/weather/stress	.001	0	1000	-100
C	A	Replacement fire	.012	0	83	0
C	B	Wind/weather/stress	.001	0	1000	0
D	A	Replacement fire	.012	0	83	0
D	B	Wind/weather/stress	.001	0	1000	0

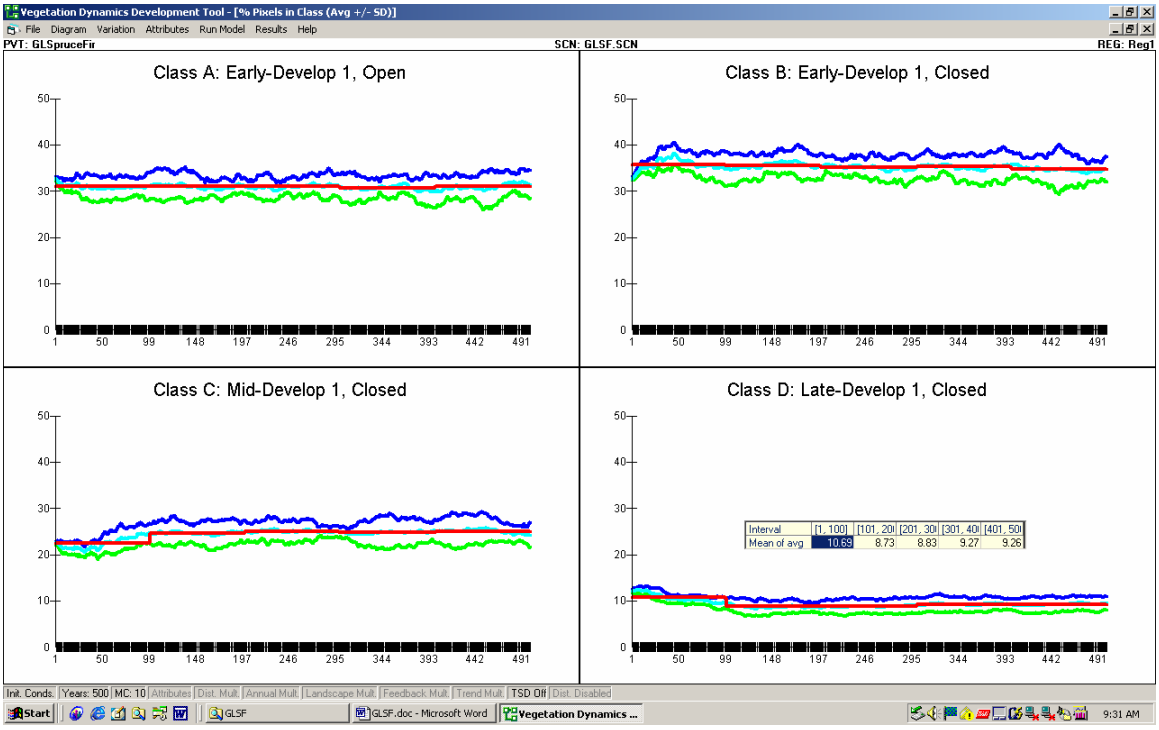
Class A – early seral aspen/birch < 40 yrs: A succeeds to mid age stands (Class B).

Class B - mid age with aspen/birch overstory and mid tolerant understory (40-100 yrs): Succeeds to class C. Replacement fires result in aspen/birch. Windthrow returns vegetation to the beginning of this class.

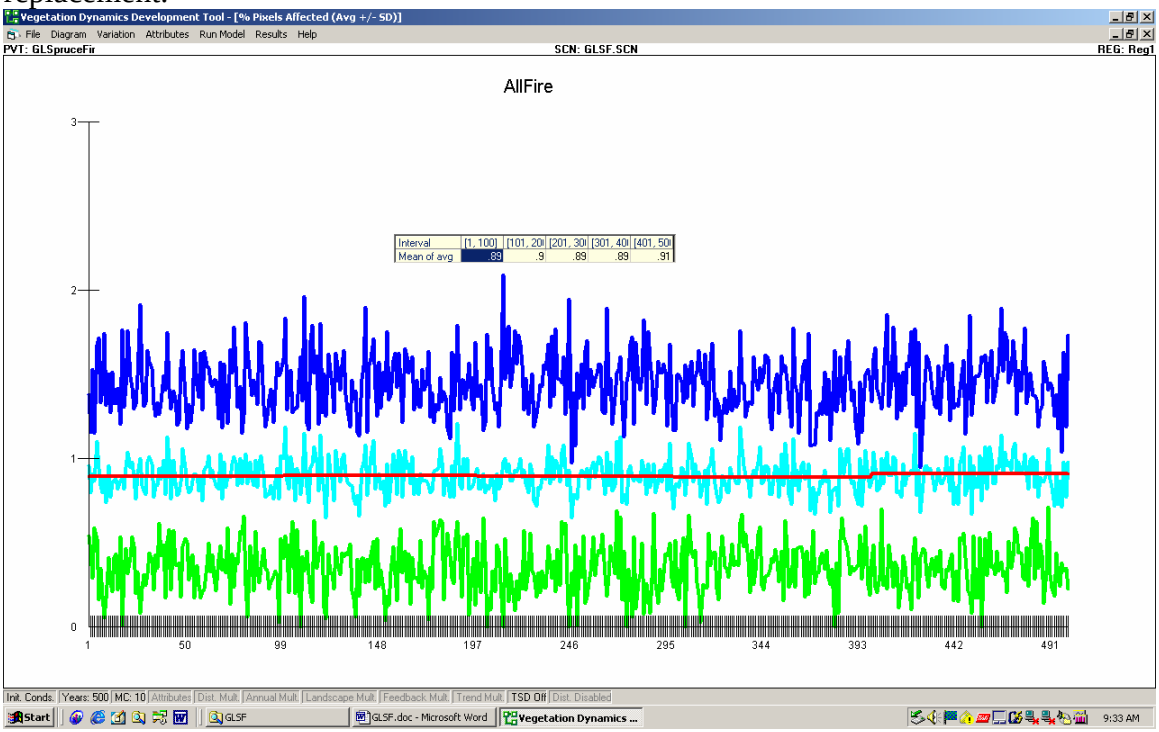
Class C – mid age stands dominated by white spruce and balsam fir (101-200 yrs): Succeeds to class D. Higher replacement fire probabilities are due to effects of spruce budworm.

Class D – old stands > 200 yrs : End point of succession. Spruce budworm increases replacement fire probability.

Results: Per cent of area by class for 500 years. Average + or - 2 SD's.



All fire frequency: 0.9 % of the area burns/year for a FRI of 100 years. All fires are replacement.



Windthrow frequency: 0.07 % of mature stands are windthrown per year for an average windthrow rotation of about 1400 years.