Fire Regime Condition Class (FRCC) Interagency Handbook
Reference Conditions

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Potential Natural Vegetation Group: Great Lakes pine forests: Jack pine

Geographic Area: Michigan, Minnesota, and Wisconsin

Description: The jack pine community is endemic to very dry, nutrient impoverished landscape ecosystems. These ecosystems occur in landforms deposited by high-energy glacial melt waters, principally outwash plains and glacial lakebeds, underlain by well-sorted coarse-textured sandy soils. In Minnesota, jack pine also occurs on bedrock controlled shallow soils with limited moisture storage capacity. It is commonly associated with barrens. Jack pine often occurs with red pine, and the community includes a spruce associate in Minnesota. Oak species and white pine may be present in low densities, and aspen and birch also occur within areas of less xeric soils. Jack pine also occurs within wetlands.

Jack pine is a fast growing, short-lived fire-dependent species that grows farther north than any other American pine and is the most widely distributed pine species in Canada. It is generally regarded as a pioneer species or "fire-disclimax", and is capable of self-replacement. In the absence of fire or other catastrophes, jack pine is succeeded by more tolerant or longer-lived species, but on the poorest, driest sites it may persist as an edaphic climax (Brubaker 1975). Jack pine is one of the most shade-intolerant trees in its native range, requiring full light for growth and survival. It usually grows in even-aged pure stands, although mixed stands also occur.

Jack pine's adaptation to catastrophic fire is largely due to its capacity to produce viable seed within a decade or so of establishment, aerial seed protection and storage in serotinous cones, delayed seed release following fire, and prolific germination of released seed. High seedling densities (2,000 to 5,000 per acre) effectively compete with other re-establishing or invading species and self-thin over time. In the southern part of its range, cones are both serotinous and nonserotinous (Zasada et al. 1992).

Following ignition, jack pine promotes crown fires due to high concentrations of volatile foliar substances, dense foliage, and retention of lower branches that form fuel ladders. Thus surface fires are not common within well-stocked jack pine communities. Fires recurring in less than 10 to 15 year intervals prevent jack pine from surviving long enough to produce viable seed, maintaining associated barrens and openlands that comprised 10-20% of the landscape.

Jack pine regenerates successfully after high intensity crown fires, although a relatively low temperature of 120°F is required to open jack pine cones, so even low intensity fires are capable of releasing seed. Jack pine trees are susceptible to mortality during or following a fire, and populations of jack pine tend to survive as seeds (McCune 1988).

Jack pine stands become susceptible to mortality through natural senescence, as well as insects and disease, after 60 to 80 years. However, vigorous trees 185 years old have been found in northwestern Minnesota. Dead stands pose a severe crown fire risk throughout the year, until snags blow down and decompose.

In the northern half of the lower peninsula of Michigan, 91% of all line trees recorded by General Land Office surveyors within xeric outwash plains were pine species (Figure 1). Jack pine represented 54% and "pine" recorded only to the genus level 17% of the total; it is likely that a

large proportion of the undifferentiated pine were jack or red pine. Red and white pine represented 31%, and early successional oak, aspen, and birch represented 4.4% of the total count of GLO line trees.

In the upper peninsula of Michigan, 81% of all line trees recorded by General Land Office surveyors within xeric outwash plains were pine species and 90% were upland conifers (Figure 2). Jack pine represented 55%, red and white pine 24%, spruce-fir 9%, and early successional aspen and birch 4.4% of the total count of GLO line trees.

In Wisconsin, 84% of all corner and quarter-corner trees recorded by General Land Office surveyors within xeric outwash plains were pine species (Figure 3). Jack pine represented 54%, red and white pine 30%, and early successional oak, aspen and birch 13% of the total count of GLO corner and quarter-corner trees. The higher proportion of aspen and birch in Wisconsin is due to less xeric soils.

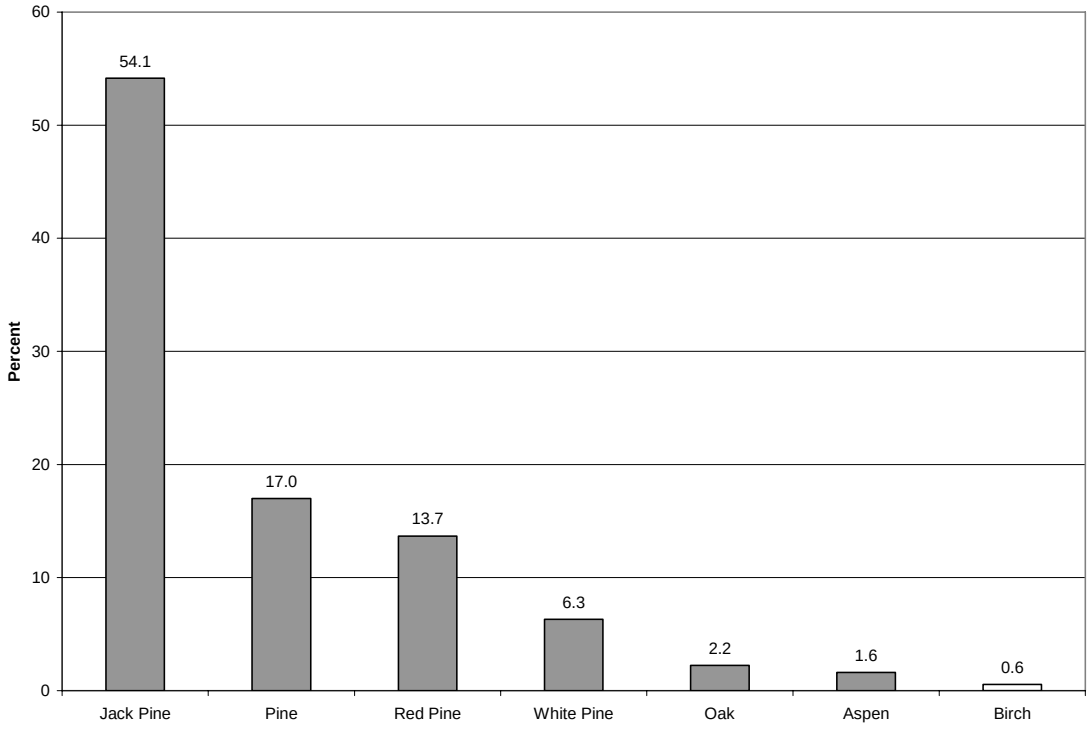

Figure 1. Percentage of trees in each species recorded within GLO line notes for the "jack pine" potential natural vegetation group of Michigan's lower peninsula.

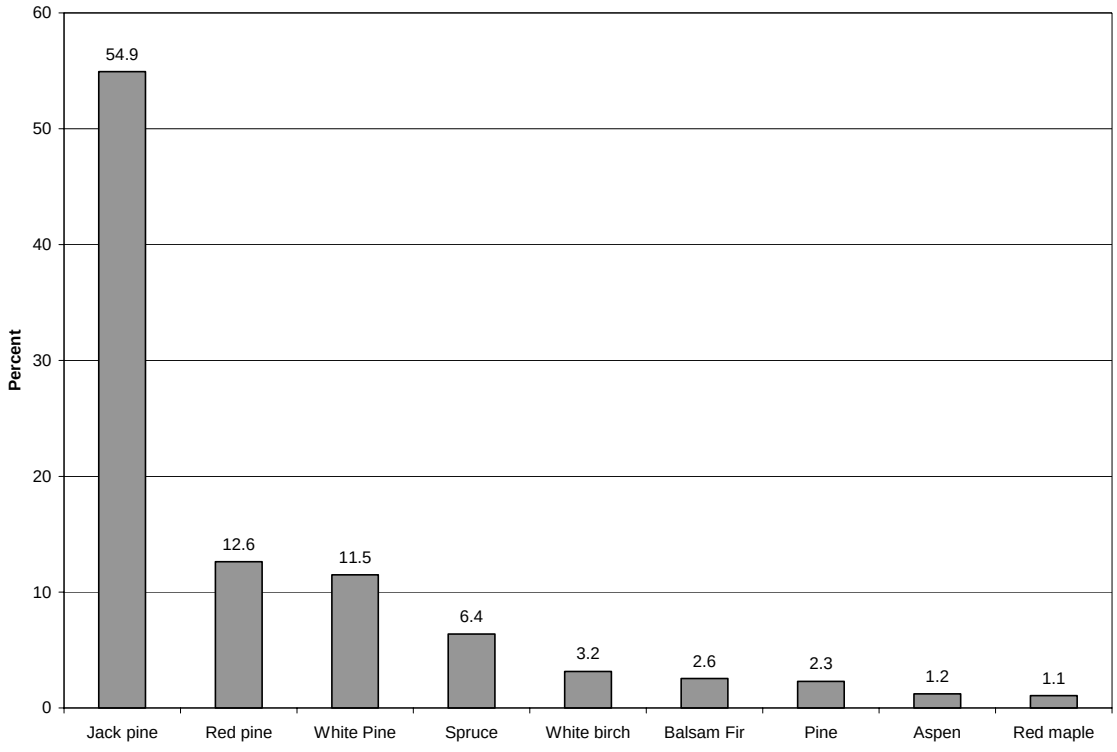

Figure 2. Percentage of trees in each species recorded within GLO line notes for the "jack pine" potential natural vegetation group of Michigan's upper peninsula.

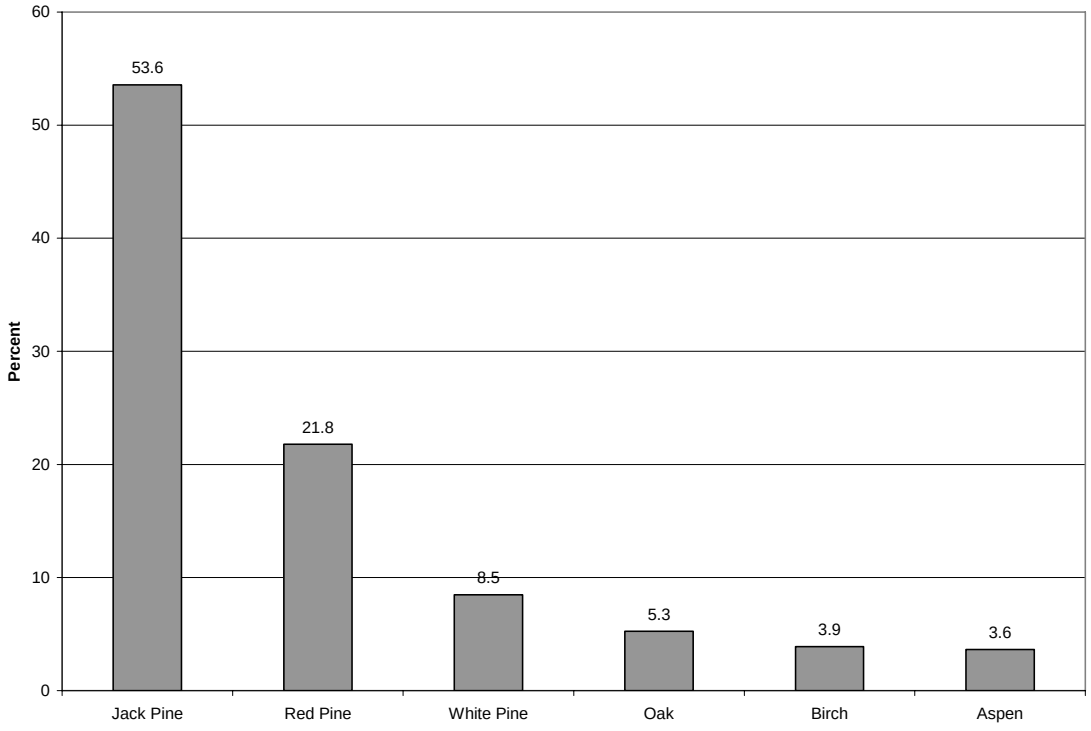

Figure 3. Percentage of trees in each species recorded within GLO corner-quarter notes for the "jack pine" potential natural vegetation group of Wisconsin.

The proportion of jack pine, and red - white pine in the GLO records is consistent with expected fire return intervals for a 50-year fire rotation based on a negative exponential curve. Roughly 80% of the total area would have escaped fire long enough for jack pine to produce viable seed (10 years) and then burn sometime within the next 50 years. Another 30% of the area would not have burned for at least 60 years, long enough for red and white pine to mature, reproduce, and develop bark thickness and canopy height necessary to survive relatively infrequent surface fires that maintained wide tree spacing, which reduced crown fire occurrence.

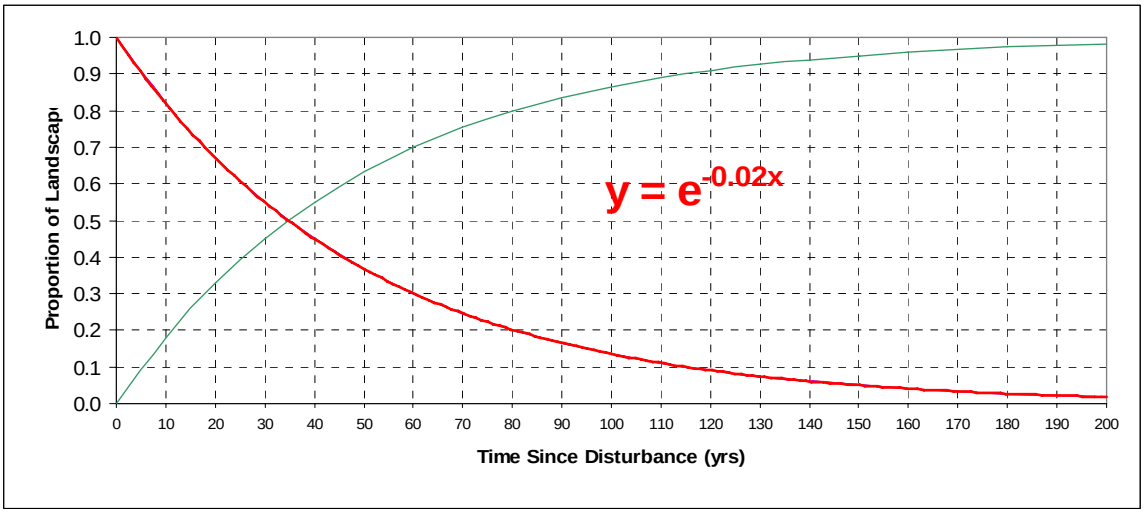

Figure 4. Fire return intervals for a 50-yr fire rotation based on a negative exponential curve.

Fire Regime Description: Jack pine occurs within fire regime group IV and III, with fires occurring every 30 to 40 years and replacement fires occurring every 50 years. Severe wind events affect mature stands on an approximate 200-year interval. This results in an overall wind rotation of 435 years.

Fire behavior in jack pine stands is usually of the highest intensity observed in the boreal forest (de Groot et al. 2004). Jack pine is not only highly adapted to frequent crown fire regimes, it usually requires catastrophic fire to regenerate successfully or to compete with longer-lived or more shade tolerant species.

Cleland et al. (2004) reported a 59-year historical fire rotation for jack pine in northern lower Michigan. Whitney (1986) reported an 80-year fire rotation, and Leahy and Pregitzer (2003) a 100-year fire rotation for jack pine in northeastern lower Michigan. Zhang et al. (1999) reported a 130-year rotation for jack pine in Michigan's upper peninsula. Heinselman (1981) reported a 50-year rotation for jack pine in Minnesota.

Ongoing research (Cleland et al. 2004a) indicates jack pine ecosystems in Michigan's upper and lower Peninsula and Wisconsin had comparable historical stand-replacing fire rotations of 50-60 years, and much shorter rotations within the openland component of this landscape ecosystem. Jack pine ecosystems embedded within a wetland matrix, principally in the eastern Upper Peninsula of Michigan and in Minnesota, are believed to have naturally longer fire rotations due to low contagion of fire from nearby communities.

Vegetation Type and Structure

Class*	Percent of Landscape	Description
A: early seral all (barrens)	20	Barrens dominated by *Carex* spp., grasses, and herbaceous plants. Trees comprise less than 10% canopy coverage.
B mid- seral open (young jack pine)	25	Young jack pine stands less than 15 years of age. Non-seed bearing.
C: mid-seral closed (mature jack pine)	40	Jack pine dominated stands 15 to 100 years. In absence of fire most jack pine die by age 100 and this class reverts to barrens (80%) or red pine (20%)
D: late-seral open (young red pine)	5	Open red pine/jack pine stands less than 50 years of age
E: late-seral closed (mature red pine)	10	Open and closed red pine stands greater than 50 years of age
Total	100	

*Formal codes for classes A-E are: AE1A, BM1O, CM1C, DL1O, and EL1C, respectively.

All classes burn at an average rate of 4% per year with the caveat that stands do not reburn for 10 years. This is equivalent to a 35-year fire return interval. Jack pine fire severity increases with age with nearly 100% mortality in mature stands. Cones are serotinous and areas quickly regenerate to jack pine. Red pine stands are more susceptible to replacement fires before age 50. Non-lethal surface fires predominate in mature red pine stands. Both species are short lived with jack pine living to about age 100 and red pine to age 150. The fire frequency and severity varies by succession class as follows. A table showing the disturbance probabilities used in the model is contained in the VDDT documentation section.

A: **Barrens**: All fires are replacement and set this class back to barrens. Without fire barrens persist for 25 years before they regenerate to jack pine (80%) or red pine (20%).

B: **Jack pine stands less than 15 years of age**. Fires are 60% replacement and 40% mixed. Since jack pine does not produce viable seed until about age 15, replacement fires result in a barren.

C: **Jack pine stands 15-100 years of age**. Fires in this class are 80% replacement and 20% mixed. Fire severity increases with age. Replacement fires result in a young jack pine stand. The few stands that escape replacement fire die after age 100 and revert to barrens (80%) and red pine (20%).

D: **Open red pine/jack pine stands less than 50 years of age**. Fires are 50% replacement and 50% mixed. Since red pine on these sites doesn't produce sufficient viable seed until age 50, replacement burns result in a barren.

E. **Open red pine stands greater than 50 years of age.** Larger red pine are more resilient to wildfire. Assumed fire severities are 90% non-lethal surface fires and 10% replacement fires. Red pine stands die after age 150 and revert to young red pine stands. Surface fires maintain stands at a lower stocking level allowing for less moisture competition for individual trees. Repeated surface fires prolong the life of the large trees.

Fire Severity	Fire Frequency (yrs)	Probability	Percent, All Fires	Description
Replacement Fire	48	.021	70	All fires in barrens and 80% of fires in mature jack pine are replacement
Non-Replacement Fire	125	.008	30	Primarily surface fire in older red pine. Mixed fire in young classes.
All Fire Frequency*	34	.029	100	

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

References

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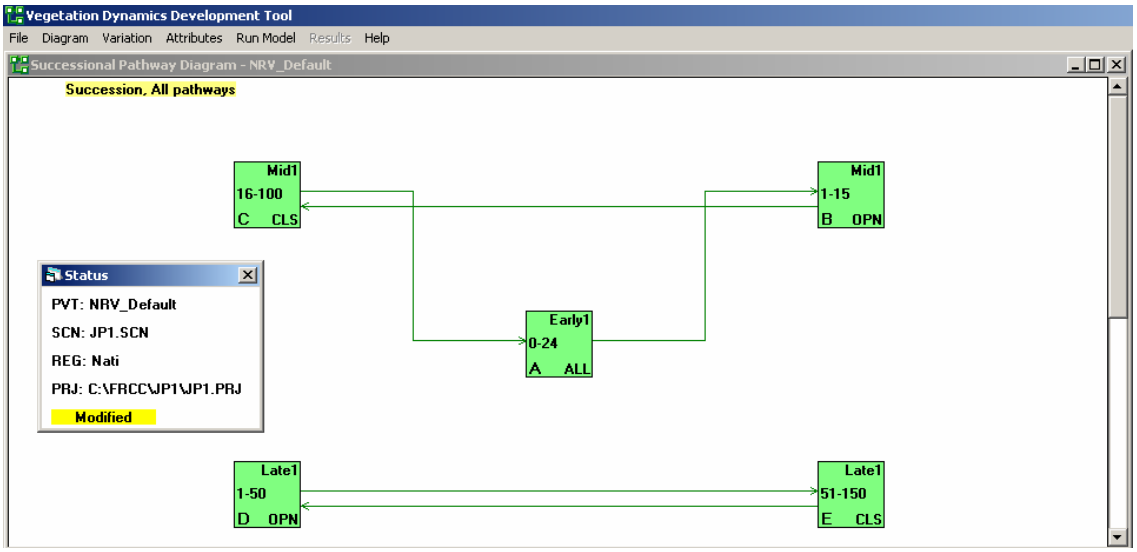
VDDT file documentation: Model JP1 located in C:/FCCC/JP1: Load VDDT text files into C:/FRCC for project file to work. Diagram shows succession only.



Disturbances by class: **Model JP1**

Class	To	Agent	Prob	TSD	Freq/ FRI	Rel Age
A	A	Replacement fire	.04	10	35	-25
A	D	AltSuccession**	.2	0	NA	0
B	A	Replacement fire	.024	10	52	0
B	B	Mixed fire	.016	10	72	0
C	A	Replacement fire	.032	10	41	0
C	C	Mixed fire	.008	10	135	0
C	B	Wind/weather/stress	.0046	0	227	
C	D	AltSuccession**	.2	0	NA	0
D	A	Replacement fire	.02	10	60	0
D	D	Mixed fire	.02	10	60	0
E	A	Replacement fire	.004	10	250	0
E	D	Surface fire	.036	10	28	-10
E	B	Wind/weather/stress	.0046	0	220	0

*** Alternative succession is only applied at the last age of the class. On the VDDT disturbance (Pathways from) table select **Display,** then **Show Ages**, to apply.*

Class A - Barrens: All fires are replacement and occur only after 10 years have elapsed since the previous fire (TSD=10). Class A succeeds to a young jack pine stand (Class B). AltSuccession disturbance is used to succeed 20% of class to red pine (class D).

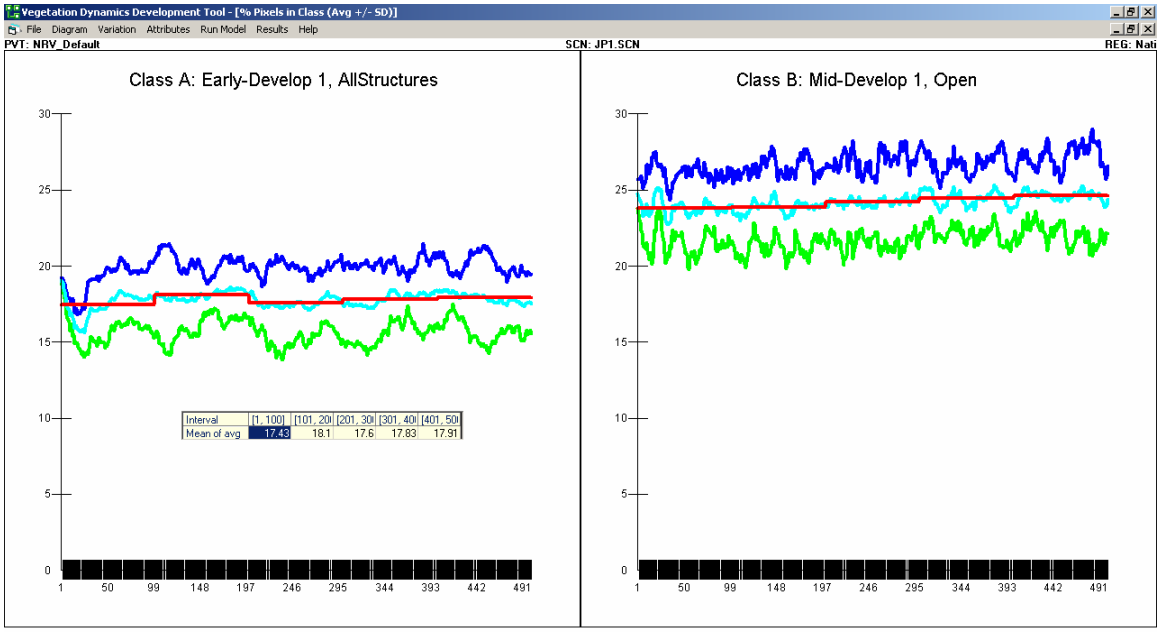
Class B - young jack pine < 15 years: Fires are 60% replacement and 40% mixed. Replacement burn areas go to barrens (class A) due to lack of jack pine seed.

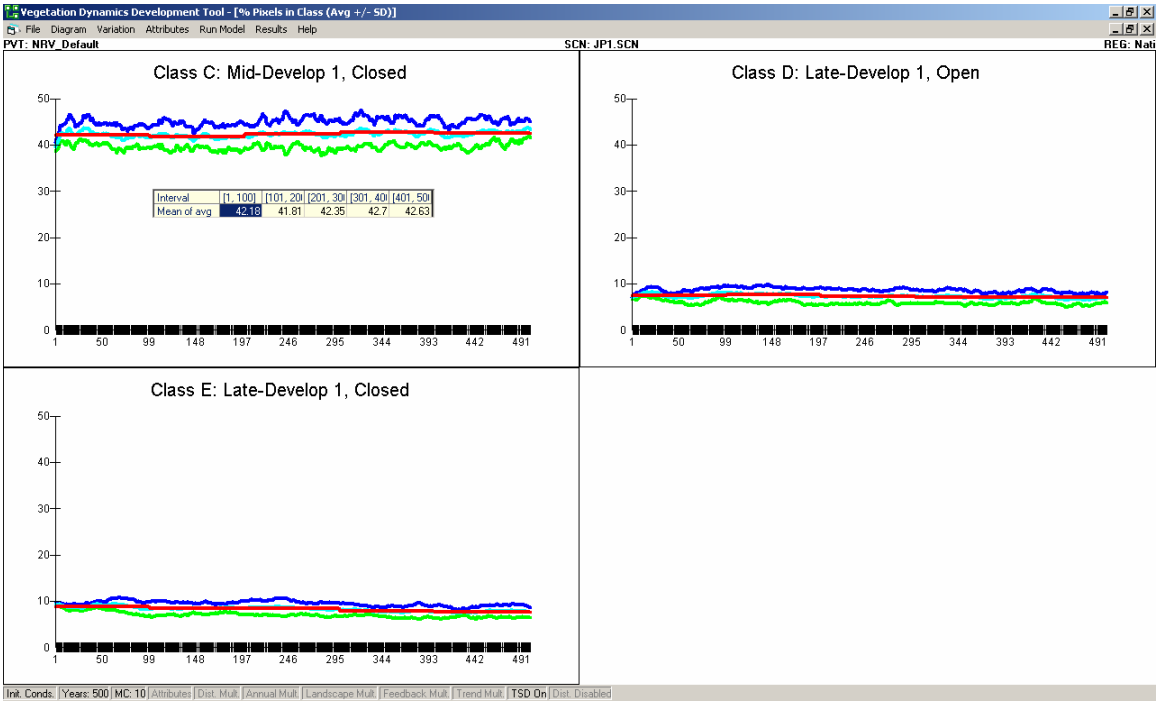
Class C – mature jack pine: Fires are 80% replacement and 20% mixed and occur 10 or more years following previous fire. Stands die when they reach 100 years and go to barrens (80%) or red pine (20%). Stands also blow down at about a 220 year interval.

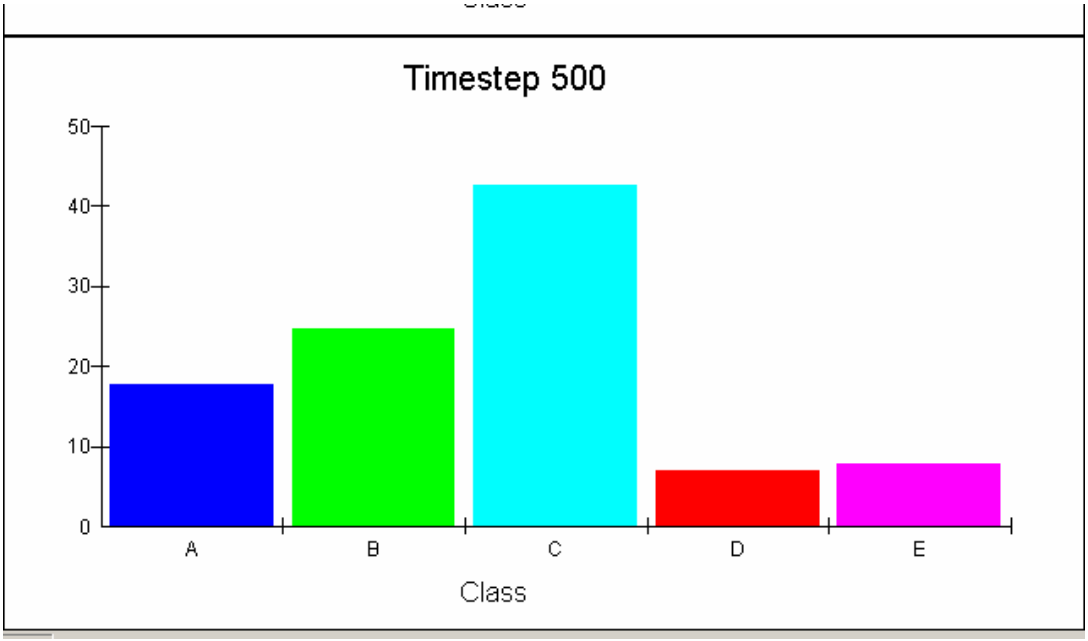
Class D – young red pine < 50 years: Fires are 50% replacement and 50% mixed. Replacement fires go to barrens (class A).

Class E– older red pine >50 years: Fires are 10% replacement and 90% surface. Replacement fires go to young red pine (class D). Stands die after age 150 and revert to young red pine. Surface fires reduce stocking and moisture competition of remaining trees, increasing the time stands can remain in this class.

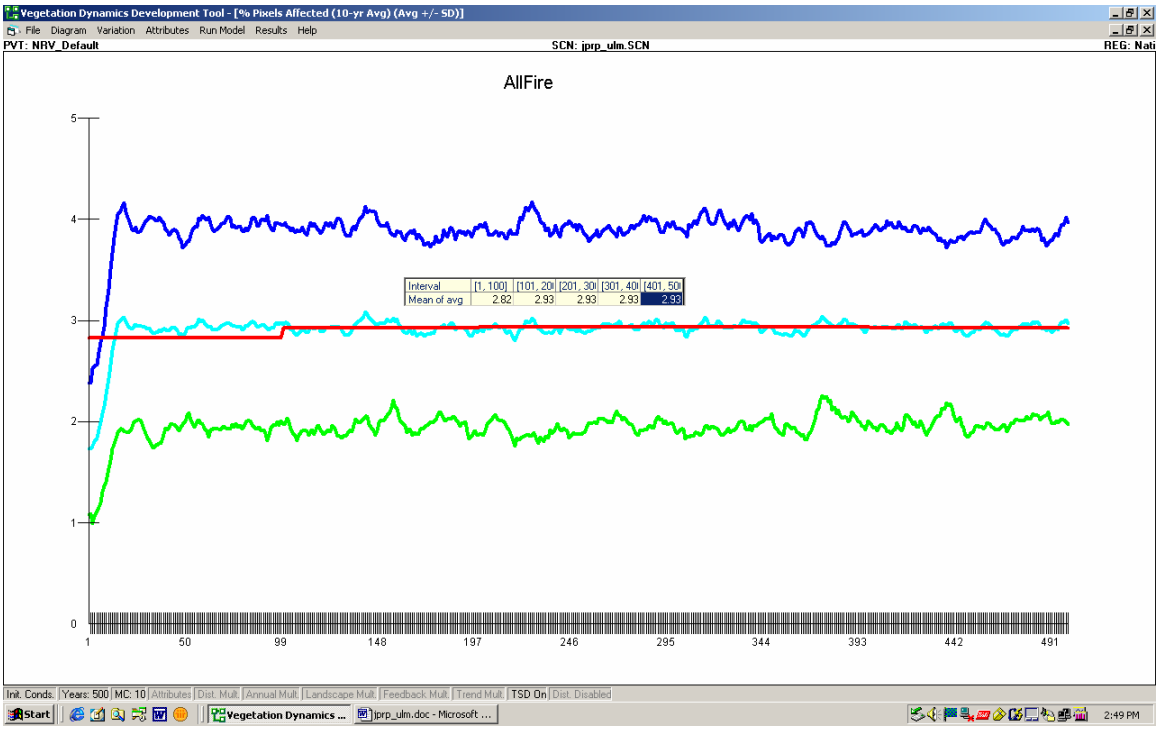
Results graphs: These graphs show the average percent of area in each class projected for 500 years. These are 10-year-average graphs + or - 2 standard deviations.



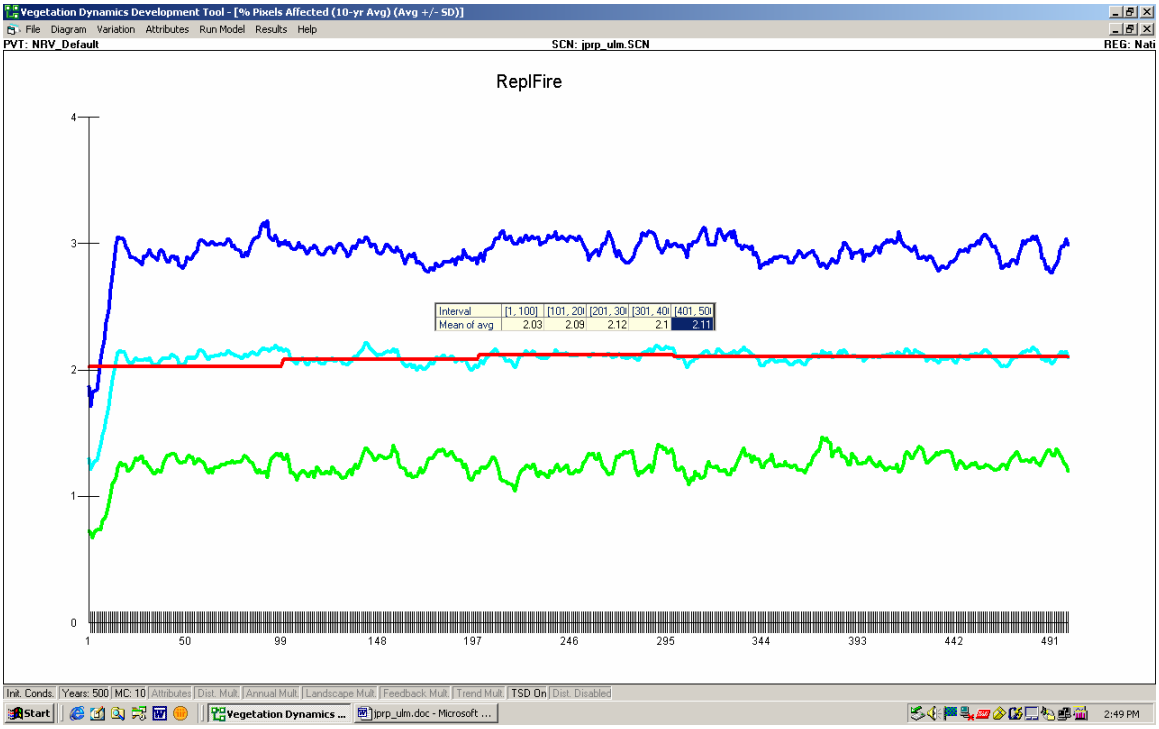

Vegetation Dynamics Development Tool - [% Pixels in Class (Avg +/- SD)]
File Diagram Variation Attributes Run Model Results Help
PVT: NRV_Default
SCN: JP1.SCN
REG: Nati
Class C: Mid-Develop 1, Closed
Interval [1, 100] [101, 20] [201, 30] [301, 40] [401, 50]
Mean of avg 42.18 41.81 42.35 42.7 42.63
Class D: Late-Develop 1, Open
Class E: Late-Develop 1, Closed
Init. Conds. Years: 500 MC: 10 Attributes Dist. Mult. Annual Mult. Landscape Mult. Feedback Mult. Trend Mult. TSD On Dist. Disabled


Timestep 500
50
40
30
20
10
0
A
B
C
D
E
Class

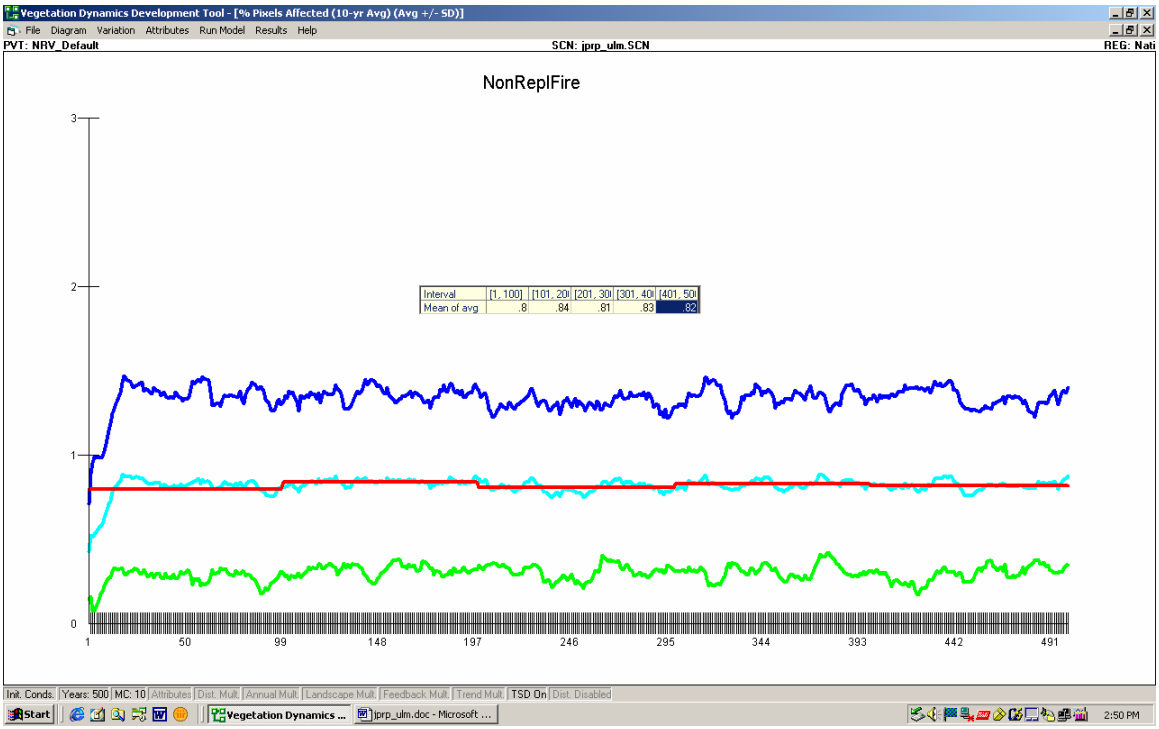
All fire frequency: Approximately 2.95% of the area burns per year for a fire return interval (FRI) of about 34 years.



Replacement fire frequency: Approximately 2.1% of the area burns per year for a replacement FRI of 48 years.



Non-replacement fire frequency: Approximately 0.8 % of the area burns per year for a non-replacement FRI of 125 years



CatastrophicWindthrow frequency: Approximately 0.23% of the area is affected by catastrophic windthrow per year for a windthrow interval of about 435 years.