Fire Regime Condition Class (FRCC) Interagency Handbook
Reference Conditions

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Date: 20 December, 2004

PNVG Code: WPHE2

Potential Natural Vegetation Group (PNVG): Great Lakes pine forests: White Pine-Hemlock #2 (white pine–cedar–fir–spruce-hemlock stands on mesic undulating glacial lakebeds).

Geographic Area: Upper Peninsula of Michigan.

Description: The hemlock – white pine PNVG in the upper peninsula of Michigan occurs primarily within extensive, flat to gently undulating glacial lakebeds (former Lake Algonquin) underlain by silty, well to somewhat poorly drained soils. Drainage catenas across interspersed poorly and very poorly drained lowlands facilitate co-occurrence of subregionally important wetland species such as cedar, balsam fir, and white spruce in upland positions with hemlock and white pine dominants. These landscape ecosystems typically have low proportions of sugar maple and associated mesophilic deciduous species due to limited soil nutrient availability, as well as low proportions of species requiring frequent disturbance such as jack pine and aspen. A relatively high incidence of blowdown due to shallow rooting, coupled with shorter-lived co-dominants susceptible to spruce budworm infestation, resulted in fuel formation and fire occurring twice as frequently within this landscape ecosystem as those supporting white pine – hemlock communities in adjacent lower Michigan and Wisconsin.

In the mid-1800's, there were 1.0 million acres of hemlock – white pine ecosystems within the 10.4 million acres of forestlands in the Upper Peninsula of Michigan (Cleland 2004a, ongoing R-9/SRS/MTU study). In descending order of occurrence based on analysis of GLO line tree observations, the dominant species recorded along section lines by GLO surveyors were hemlock, white pine, cedar, fir, and spruce (Figure 1). Early successional aspen and white birch comprised 10% of the GLO line trees, and late successional inclusions of sugar maple and yellow birch comprised 9%.

Roughly half of this white pine –hemlock PNVG was in an old growth state calculated using an age threshold of 150 years, a fire rotation of 250 years, and a negative exponential fire return interval probability distribution function (Figure 2). Much of this old growth consisted of relatively low densities of tall, large diameter trees with subcanopies of shade-tolerant species, particularly balsam fir. Old-growth white pine – hemlock stands are often partially multi-aged (Holla and Knowles 1988) or uneven-aged due to continuous recruitment caused by local disturbances (Quinby 1991).

Once white pine has matured and attained larger diameters and crown height, widely-spaced dominants were highly resistant to intense surface or maintenance fires (Beverly and Martell 2003). Other associates, including hemlock, white spruce, and balsam fir were injured or killed by intense surface fires, and all species suffer high rates of mortality following crown-fires. The successional dynamics of this ecosystem after mixed or severe crown fires may involve establishment of aspen-birch, cedar, or white pine following the disturbance, with subsequent succession to mixed white and red pine, spruce, and fir, followed by late successional gap-phase invasion of hemlock beneath white pine during long fire-free periods (Davis et al. 1992).

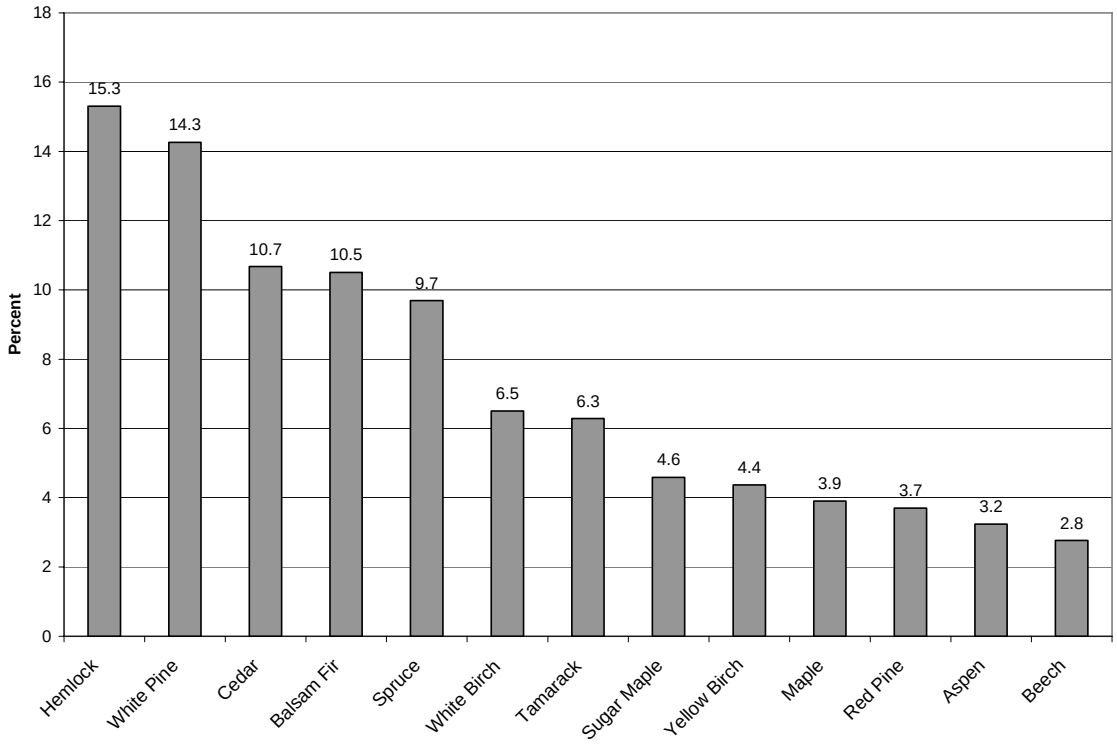

Figure 1. Percentage of trees in each species recorded within GLO corner notes for the "white pine - hemlock" potential natural vegetation group of Michigan's Upper Peninsula.

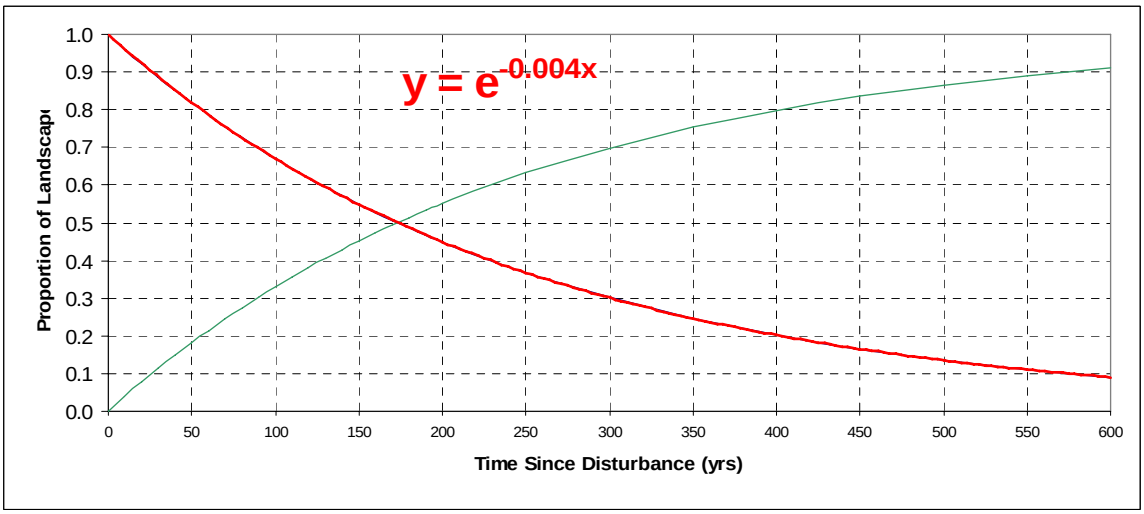

Figure 2. Fire return intervals based on a negative exponential curve for a fire rotation of 250 years

Rogers (1978) reported only 8% of the hemlock stands sampled from Wisconsin to Nova Scotia were even-aged, indicating that very few of the hemlock stands were initiated after a catastrophic event such as a wildfire. In an old-growth white pine forest of Canada, white pine persisted as the dominant species over a seven-century period, indicating that white pine can be self-replacing (Quinby 1991). In a study of old growth white pine in Canada, Guyette et al. (1995) reported that canopy dominance and tree size suggested an even-aged structure, whereas actual ages of dominant trees ranged from 267 to 486 years. White pine older than 400 years made up 20% of the dominant trees, 52% were 300 to 400 years old, and 28% were 250 to 300 years old. Diameter distributions approximated a reverse-J shape curve, suggesting an uneven-aged or multi-aged forest.

Fire Regime Description: Fire regime group III, with fires occurring every 100+ years and mixed severity. Severe wind events affect mature stands on an approximate 500-year interval

The hemlock – white pine forests of the upper peninsula of Michigan were disturbed by large-scale stand replacing crown fires within rotations of 200 – 300 years (Cleland et al. 2004a) and wind events of approximately 500-year rotations. Catastrophic disturbances, low-intensity small surface fires, windthrown trees, and the death of large individual trees through biological or other agents, interacted to regulate stand-scale gap dynamics.

The complex structure and age-class distributions of this ecosystem are due to these two distinct disturbance regimes, and associated successional dynamics. Broad-scale crown fires occurred very infrequently, selecting for pyrophilic species capable of reproducing in full-light conditions following stand-replacing disturbance. Fine-scale, single or group-tree mortality and blowdown occurred continuously, and selected for shade-tolerant and mid-shade-tolerant species.

Successional trajectories were historically regulated by disturbance regime, as well as landscape-level patterns in communities and environment, and localized edaphic conditions. Landscape-level patterns of lakes, wetlands, openlands, and other fuel discontinuities determined fire-exposed versus fire-protected landscape positions (Dovciak et al. 2003). Within landforms, localized conditions of soil texture and drainage, and resulting gradients of available nutrients and moisture, impeded invasion by nutrient-demanding, shade-tolerant hardwoods (Rogers 1978).

Preferential recruitment of hemlock beneath white pine and development of mor-like soil organic horizons within hemlock stands that inhibited shade-tolerant hardwood invasion (Davis et al. 1992), are examples of biologically mediated, successional dynamics. All these natural processes and factors have had a strong selective effect on the age, structure, and composition of these forests.

Vegetation Type and Structure

Class*	Percent of Landscape	Description
A: post replacement Early seral	10	Stands primarily comprised of early seral aspen, birch, and other hardwood species
B: mid-seral	20	Mixed white oak, red oak, and red maple stands. White pine will develop in the understory of these stands and eventually overtop them.
C late open	25	Red pine and young white pine stands generally < 100 years of age. Succeed to older white pine stands
D: late closed	45	Mature white pine stands. Over time, and in fire's absence, an understory of large hemlock may develop
Total	100	

Fires occur on about a 135-year return interval. Approximately 55% of these fires are replacement making this a mixed severity regime. Fires in early seral aspen/birch stands (Class A) are replacement and these stands vigorously resprout. Fires in mixed oak and maple stands (class B) are 50% replacement and 50% mixed. Replacement fires result in either an early-seral aspen/birch stand or the oak may resprout and result in a young oak stand. Stands that escape replacement fire develop a while pine understory and succeed to a mature white pine/hemlock stand.

In the absence of fire stands develop a white pine understory and succeed to mature white pine/hemlock. An even mix of replacement and mixed fires is assumed in red and white pine stands (Classes C and D). Replacement fires either revert the stand to early seral (Class A) or back to a young pine stand. The result of a replacement fire is largely dependent upon the age of the stand burned and the ability of red and white pine to reseed the burned area.

Fire Severity	Fire Frequency (yrs)	Probability	Percent, All Fires	Description
Replacement Fire	250	.004	55	
Non-Replacement Fire	290	.0034	45	Primarily mixed severity fires.
All Fire Frequency*	135	.0074	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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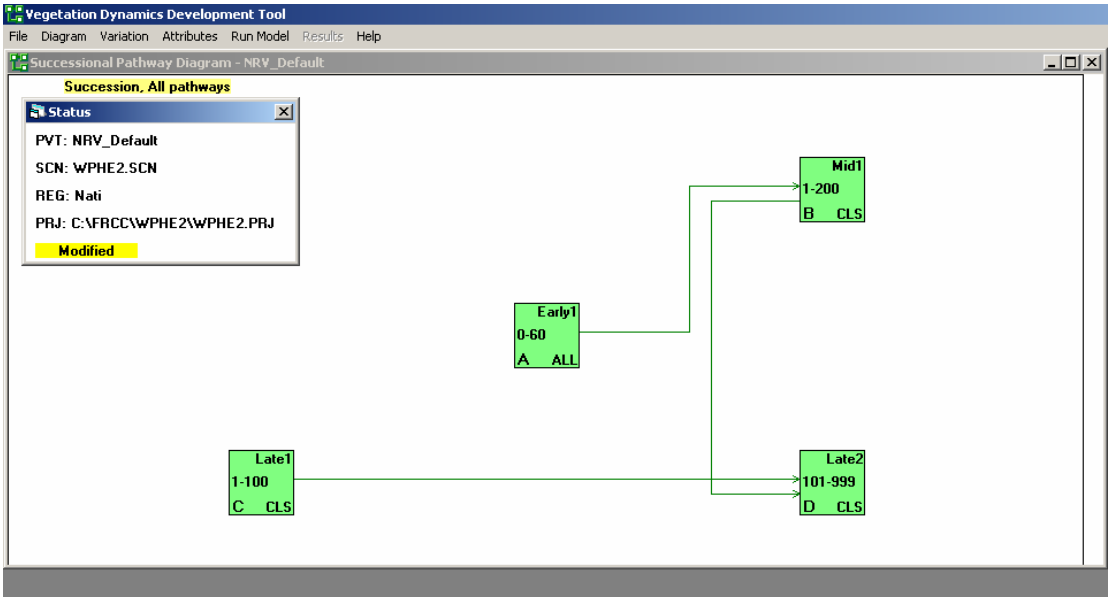
VDDT file documentation

Model WPHE located in C:/FCCC/WPHE: VDDT text files must be loaded into C:/FRCC for project file to work. The diagram shows succession only.



Disturbances by class: Model WPHE2

Class	To	Agent	Prob	TSD	Freq/ FRI	Rel Age
A	A	Replacement fire	.0075	10	143	-60
A	A	Wind/weather/stress	.001	0	100	-60
A	C	AltSuccession**	.2	0	NA	0
B	A	Replacement fire	.001875	0	533	0
B	B	Replacement fire	.001875	0	0	-200
B	B	Surface fire	.00375	0	267	0
B	B	Wind/weather/stress	.0015	0	667	-200
C	A	Replacement fire	.001875	0	533	0
C	C	Replacement fire	.001875	0	533	-100
C	C	Mixed fire	.00375	0	267	-25
C	C	Wind/weather/stress	.001	0	1000	-100
D	A	Replacement fire	.00075	0	1333	0
D	C	Replacement fire	.0030	0	333	0
D	D	Surface fire	.00375	0	267	0
D	C	Wind/weather/stress	.002	0	500	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 – Early seral Aspen/Birch: All fires are replacement and occur only after 10 years have elapsed since the previous fire (TSD=10). Class A succeeds to an oak/red maple stand (class B). AltSuccession is used to succeed 20% of class to young red pine/white pine (class C).

Class B -Mid seral Oak/red maple: These stands may persist for 200 years without fire disturbance. They eventually develop a white pine understory that overtops the hardwoods and succeed to class D.

Class C - Red pine and young white pine stands generally < 100 years: Replacement fires in stands < 50 years old revert to aspen/birch due to lack of pine seeding. Older stands, when burned, are assumed to regenerate to pine.

Class D – Mature white pine stands > 100 years: A small proportions of stands (20%) revert to aspen/birch following replacement fire. The remainder regenerate to pine.

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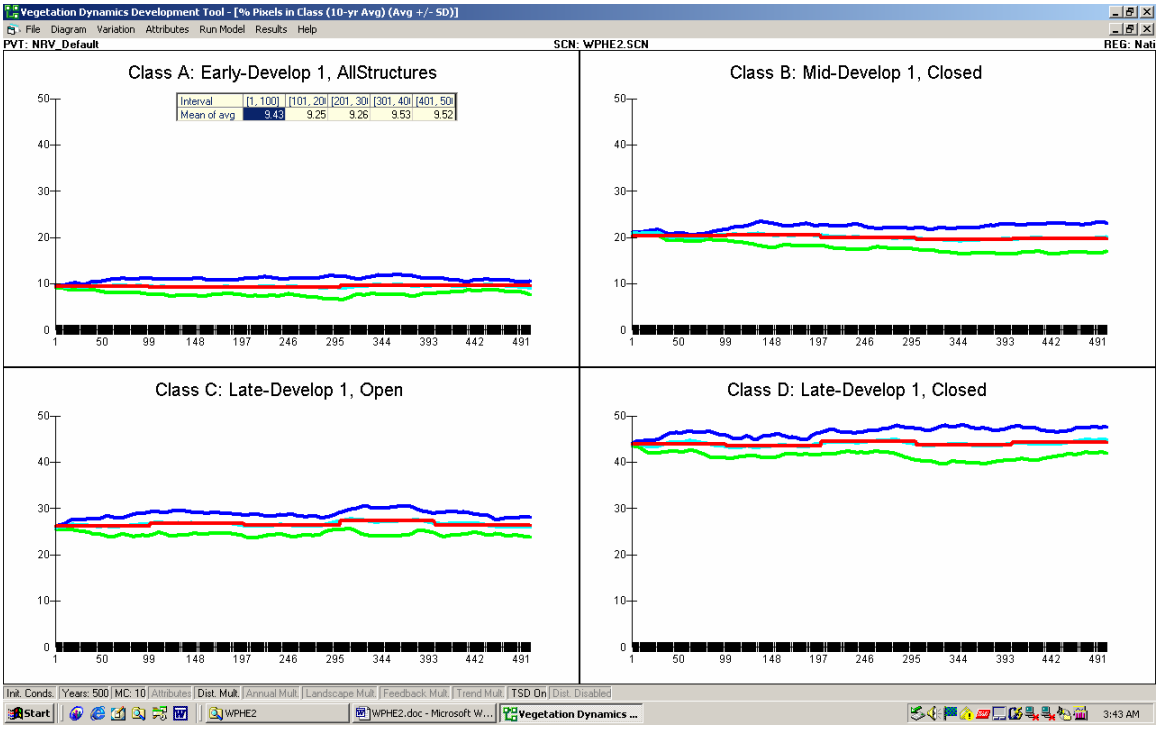
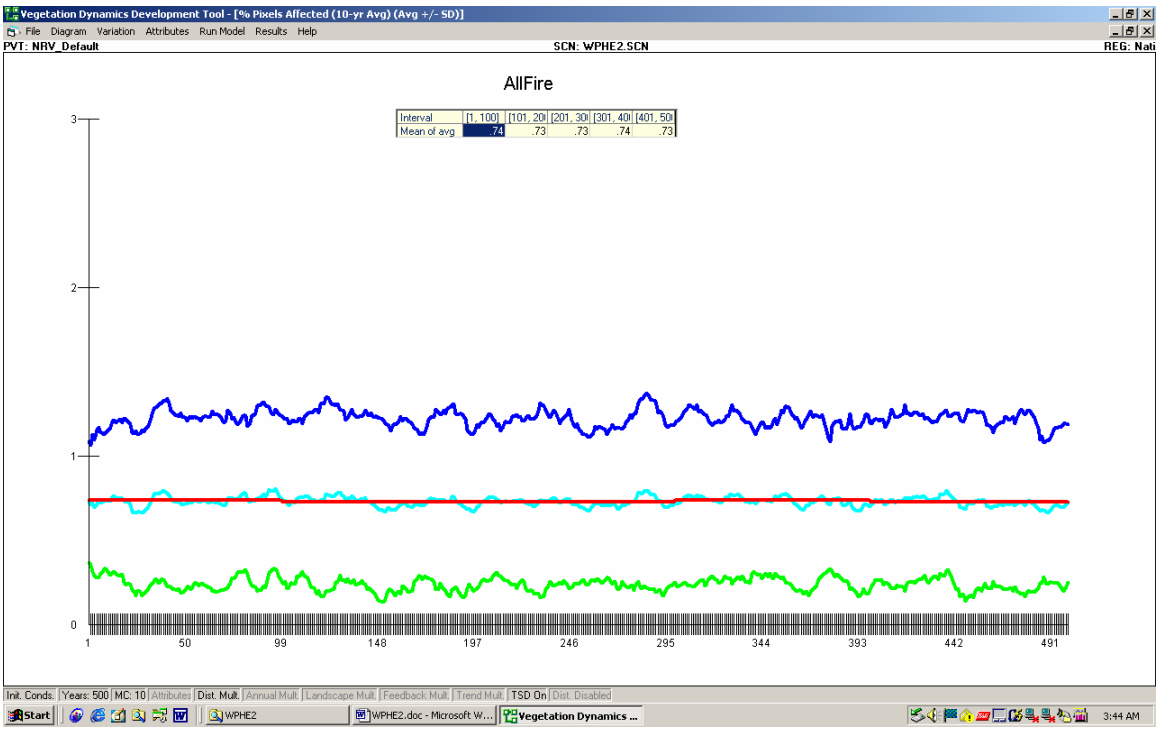
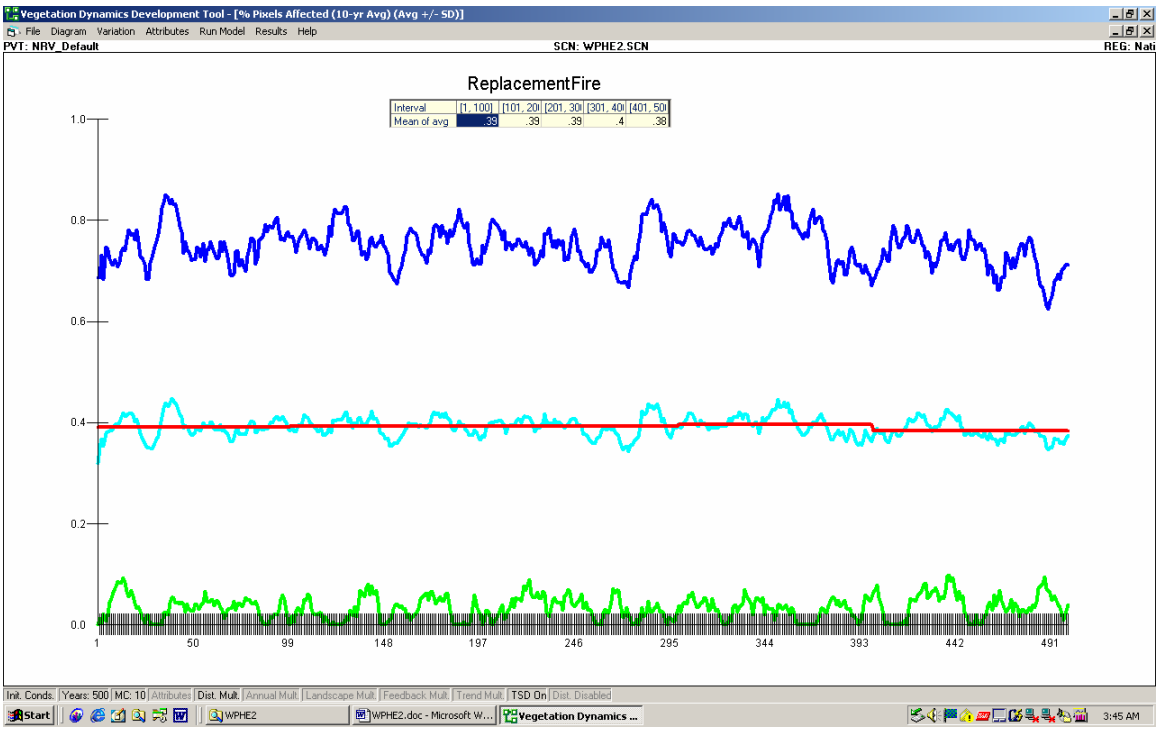
Results graphs: These graphs show the average percent of area in each class projected for 500 years. These are 10-year-average graphs + or - 2 SD's.



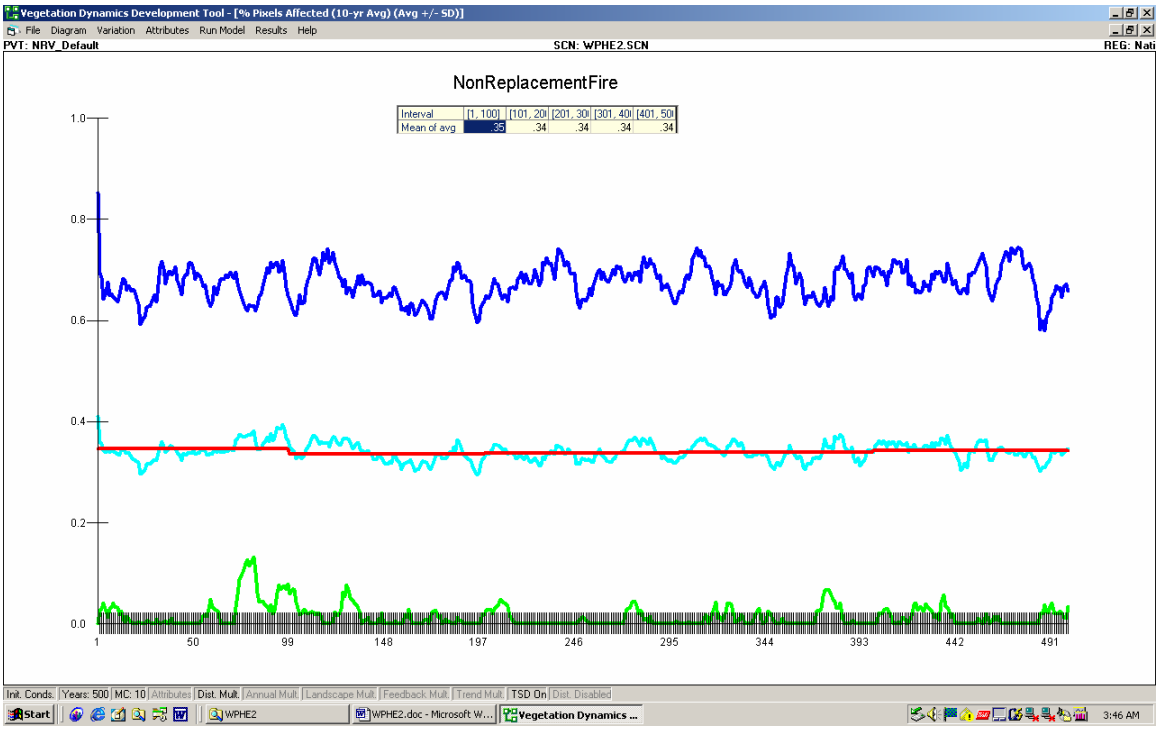
All fire frequency: Approximately 0.74% of the area burns per year for a FRI of about 135 years.



Replacement fire frequency: Approximately 0.4 % of the area burns per year for a replacement FRI of 250 years.



Non-replacement fire frequency: Approximately 0.34 % of the area burns per year for a non-replacement FRI of about 290 years.


Vegetation Dynamics Development Tool - [% Pixels Affected (10-yr Avg) (Avg +/- SD)]
File Diagram Variation Attributes Run Model Results Help
PVT: NRV_Default
SCN: WPHE2.SCN
REG: Nati
NonReplacementFire
Interval [1, 100] [101, 20 [201, 30 [301, 40 [401, 50
Mean of avg .35 .34 .34 .34 .34
1.0
0.8
0.6
0.4
0.2
0.0
1 50 99 148 197 246 295 344 393 442 491
Init. Conds. Years: 500 MC: 10 Attributes Dist. Mult. Annual Mult. Landscape Mult. Feedback Mult. Trend Mult. TSD On Dist. Disabled
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WPHE2
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