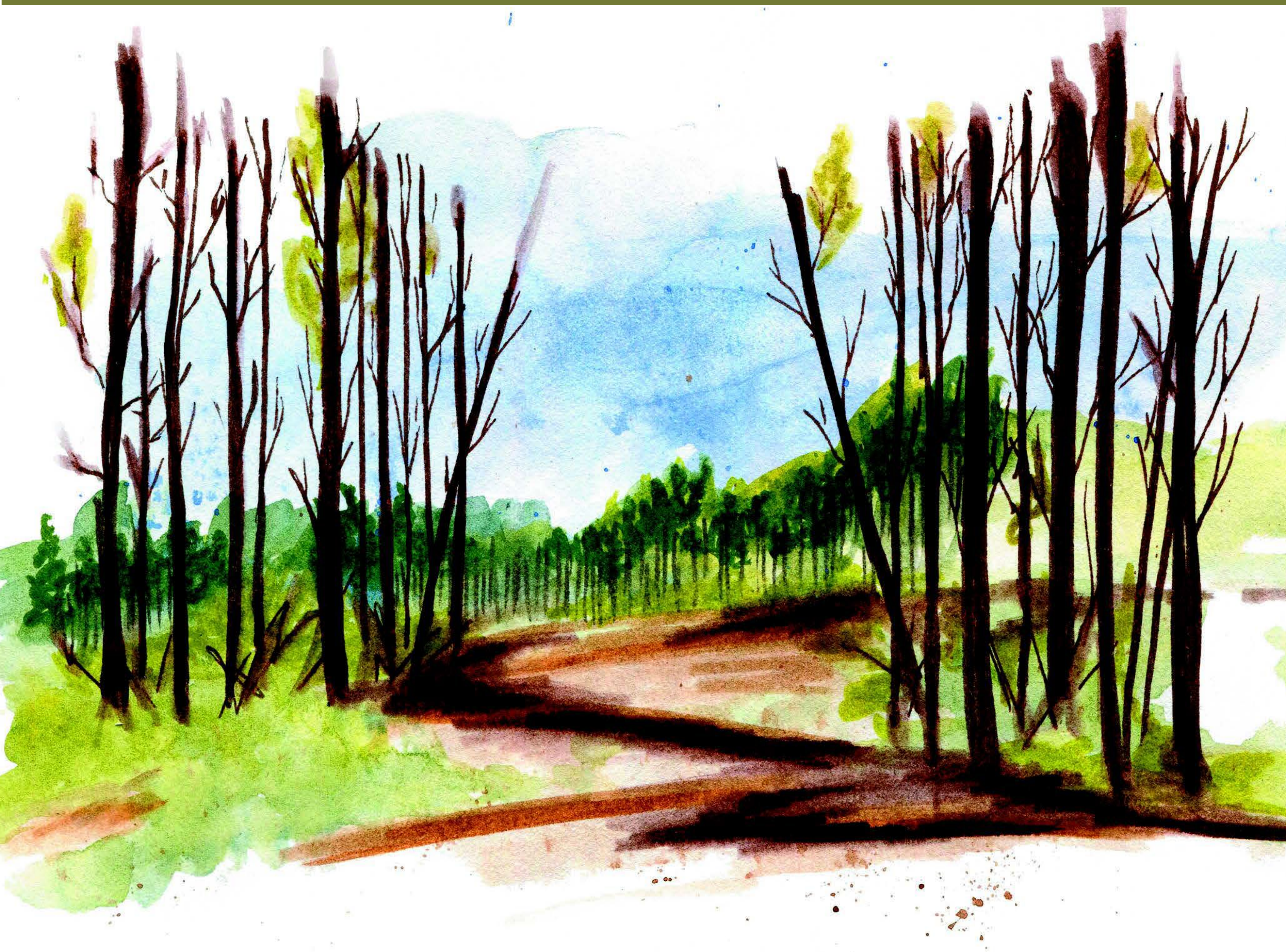
Healthy Landscapes Program QuickNotes #1–50



March 2000 – March 2020

FMF Natural Disturbance Program Research

Quicknote No. 1 - March, 2000

Disturbance Rates and Cycles

By: David W. Andison

One of the most common questions asked concerning forest fire regimes is that of frequency of occurrence. There are two ways of considering this question. The most obvious summary is the average number of years between fire events (e.g., the cycle). One can also derive an estimate of the rates of burn through time. Both of these metrics are summarized in the table below for the study area.

The ecological natural subregions are a valuable means of stratifying the landscape. The differences between the rates of burning through time for each area suggest that fire is acting differentially at this scale. These differences can be related to climate, tree species dominance, and even historical lightning strikes. Natural subregions with higher fire cycles generally have cooler, wetter climates, and less lightning activity.

Disturbance Rates and Cycles for the FMF Study Area

Period	Jasper N Park		Weldwood FMA			ANC FMA		
	Montane	Subalp.	Subalp	Lower F.	Upper F.	Subalp.	Lower F.	Upper F.
1931-50	8	6	1	2	2	0	9	2
1911-30	17	12	16	11	8	14	12	22
1891-1910	50	25	23	11	22	7	21	42
1871-90	20	4	27	53	51	38	75	57
1851-70	24	12	4	55	36	16	53	38
1831-50	6	5	27	67	47	74	66	50
1811-30	31	9	5	6	0	15	36	20
Cycle (yrs)	70-90	130-190	110-140	65-75	80-90	80-90	50-60	60-70
Area (ha)	80,000	400,000	245,000	296,000	587,000	20,000	193,000	151,000

During extreme periods of fire activity, trends are noted across several adjacent zones. For instance, between 1831 and 1850, all parts of the FMF on the east side of the mountains experienced extremely high levels of burning, while on the west side, fire activity was minimal. The one pattern consistent across all natural subregions is the tendency for burning activity to vary widely. In any one 20-year period, the amount of area burnt in any single landscape ranges between zero and more than 70%.

Finally, it is encouraging to note at least a moderate level of consistency between fire activity in adjacent, but identical natural subregions. The lower foothills area of both the Weldwood and ANC areas not only have the highest levels of overall fire activity, but the level of fire activity through time is moderately consistent. However, in general the ANC FMA has experienced higher levels of fire activity than has the Weldwood FMA.

FMF Natural Disturbance Program Research

Quicknote No. 2 – May 2000

Natural Sub-regions: Are They Meaningful?

By: David W. Andison

You bet they are. Contrary to the findings from other natural disturbance studies, the Alberta ecological natural sub-regions prove to be powerful means by which to differentiate historical fire activity and patterns in the Foothills Model Forest. Recall from Quicknotes #1 that the range of long-term fire activity, or the "fire cycle", varied by natural sub-region. These cycles are repeated for four adjacent natural sub-regions in Table 1. Also shown in Table 1 is an indication of the amount of forest that exists in large even-aged patches – a rough indication of relative fire size. Upon closer inspection, one begins to see that there are some good reasons for these differences in fire size and frequency.

Table 1. Overview of Some Characteristics of Natural Sub-Regions of the FMF

	Jasper N Park		Weldwood FMA	
	Montane	Subalpine	Lower Foothills	Upper Foothills
Area (ha)	80,000	400,000	296,000	587,000
Fire Cycle (yrs)	70-90	130-190	65-75	80-90
% Area in Patches >2,000 ha	45	66	33	76
Lightning hits/1,000 ha	17	11	58	48
Growing Degree Days	1185	903	1121	880
Mm Rain / yr	244	328	370	403
Cm Snow / yr	124	162	144	233

Table 1 tells an interesting, but logical story. Lighting hits represent the historical risk of ignition. Growing-degree-days are a rough indication of temperature conditions conducive to fire growth, and length of the fire season. The amount of rain and snow suggest how flammable the forest is. So, for example, although the Montane has low ignition probability, it has the highest number of growing degree days, and the lowest amount of precipitation. It is no wonder that despite being very linear, the Montane burns fairly often, and in fairly large patches relative to the small area (80,000 ha). On the other hand, the much larger Lower Foothills area burns even more often, but apparently in smaller bits. This can be explained by far greater lightning activity producing more fire starts, combined with much higher levels of precipitation, which would reduce the chances of any single fire from getting very large. Fire activity in the Upper Foothills and Sub-alpine sub-regions can be similarly understood through a combination of historical ignition probabilities, and fire weather indicators.

This is good news for research interpretation. Natural Sub-regions are already a part of the culture and technology of forest management on both sides of the mountains. The natural disturbance research findings fully support the use of these spatial strata for planning purposes in this part of Alberta.

FMF Natural Disturbance Program Research

Quicknote No. 3 – July 2000

Fire Control Impacts: Real or Imagined?

By: David W. Andison

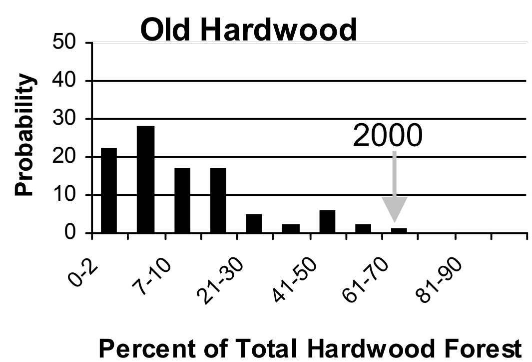
Fire control is very real to our partners. Jasper National Park, for instance, has been fighting fires since about 1930. Since then, the rate of burning has declined dramatically. In the Table below, the percent of forest disturbed over the last 60 years stand out in stark contrast to the estimates of burning for the previous 140 years. Not once since we have been fighting fires has the 20-year rate of burning exceeded even one percent.

Estimated 20-Yr Burning Rates in JNP			
20-Year Period	% Forest Burnt in each 20-Year Period		
	Jasper Ecological Zone		
	Montane	Lower Subalpine	Upper Subalpine
1971-1990	*0*	*0.2*	*0.2*
1951-1970	*0*	*0.7*	*0.2*
1931-1950	*0.3*	*0.5*	*0.2*
1911-1930	6	7	4
1891-1910	17	14	7
1871-1890	54	32	7
1851-1870	21	5	1
1831-1850	27	15	6
1811-1830	9	6	2
1791-1810	13	10	6

The shift in Jasper "old growth" forest over the same period is even more striking. For instance, in 1930, forests older than 100 years in the Montane covered 21% of the area, compared to 78% today. In the Upper Subalpine just 8% of the forest was older than 300 years, compared to 25% today.

Weldwood has even better evidence to suggest that fire control is real. A simulation exercise that projected historical disturbance rates and sizes across the FMA, suggests that some of the "protected" areas are creating historically unprecedented situations. Model output (below) shows that historically, Old Hardwood in the Lower Foothills usually ranged between zero and about 20 percent. After 50 years of fire control, the 64% Old Hardwood found today is beyond "natural" levels.

It is difficult to argue with these numbers. Fire control has probably been the single most important cultural impact on FMF landscapes over the last several decades. Now we have large quantities of old forest, and higher than normal fire danger. The risks are as much ecological as they are cultural.



FMF Natural Disturbance Program Research

Quicknote No. 4 – September 2000

Historical Fire Sizes. Easy one… Right?

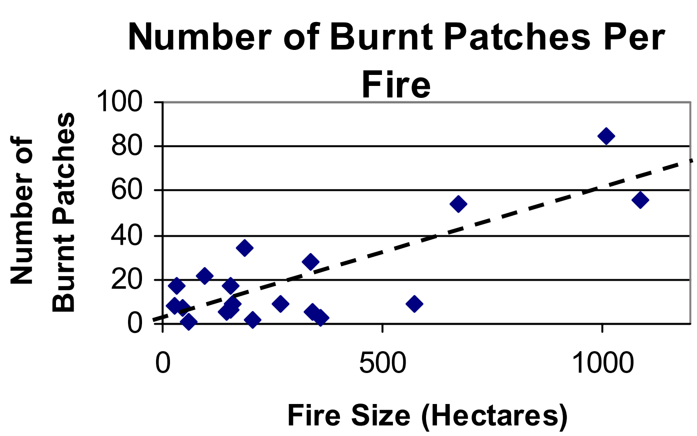
By: David W. Andison

Not necessarily. Fire size is one of the most fundamental aspects of natural disturbance pattern. Such information can be easily and directly compared to managed landscapes. The best way to estimate fire size is to have lengthy and high quality historical fire records - which are not common. The next best thing is to estimate sizes from the current landscape using GIS software. However, there are three problems with leaving it at that, and calling it a "natural" pattern.

First, the current landscape is probably not very natural. Cutblocks, roads, and other human activities are prevalent on most of our landscapes. Luckily, such activities create "holes", and in many cases, records exist. Historical maps and photos also commonly provide an excellent means of reconstruction. In other words, it is possible to fill in these holes with a high level of confidence.

The second problem is that fires burn on top of other fires. A 50 year-old stand is just a fire that burnt 50 years ago. But you would not expect to find all of the original boundaries to, or area of, that 50 year-old fire because of the subsequent fires that burnt over it. So as time progresses, the area of older fires declines, and is broken up into smaller patches by more recent fires. Therefore, only the most recent fires – the youngest forest on the landscape – truly represent the sizes of fires.

The last problem is that fires create multiple burnt patches. As the figure below demonstrates for the Alberta Foothills, as fire size increases, so do the numbers of patches each fire creates. For instance, a 1,000 hectare fire on the FMF creates, *on average,* about 60 burnt patches. By not accounting for patch clustering, patch size may be "natural", but landscape pattern will not be.



Fire and patch size estimates are not as simple as one might assume. Find out where the data came from and how it was compiled. By not accounting for the issues discussed here, size estimates can be inaccurate, biased, and in the end, not very natural.

FMF Natural Disturbance Program Research

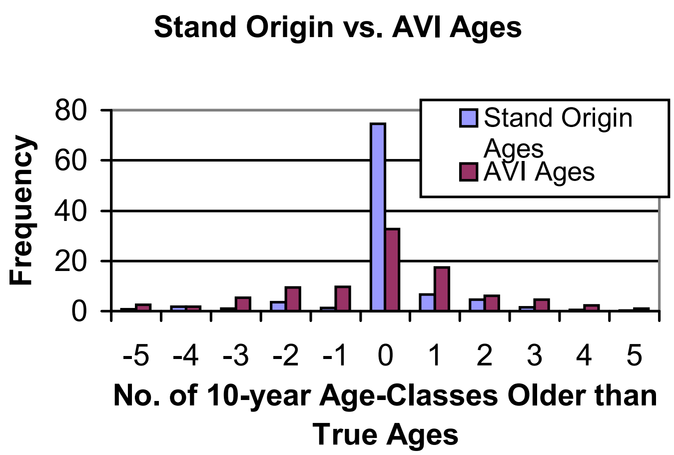
Quicknote No. 5 – November 2000

Ages, Inventories, and Pattern

By: David W. Andison

The simplest indicators of landscape pattern can be thwarted by the simplest of problems: raw data. As it turns out, the raw data for most of Alberta is less than ideal for describing fire history.

If we compare several thousand plot ages across a million hectares of the Weldwood FMA with a) forest inventory ages, and then b) stand-origin ages, the results clearly demonstrate the superior spatial precision of the stand-origin map (75% in the right age-class) compared to the AVI data (32% in the right age-class).



The increase in precision translates directly to higher confidence in estimates of same-aged patch sizes, shapes, and adjacencies. The ability of inventory ages to accurately represent spatial relationships is thus limited to generalizations using class data (lumped into 30 or 40 year classes for instance).

On the other hand, inventory age data do not show any strong bias – the age error in the AVI is split equally between being older and being younger than the actual age. This means that non-spatial summaries (of age-class distributions) calculated from inventory age data are probably legitimate.

The problem is only serious to those who desire a more detailed understanding of landscape fire history. Non-spatial age-class distributions, and cursory patch size and shape summaries are a strong start to any natural disturbance research effort. However, more precise spatial relationships such as actual fire sizes or shapes, or higher resolution pattern studies (of fire refugia for instance) are only possible with stand-origin data, which is both time-consuming and expensive to gather.

Unfortunately, the office and field sampling procedures for AVI and stand-origin mapping are different in many ways. Any decision to upgrade AVI ages to stand-origin quality must carefully consider the costs and benefits. In the meantime, any analysis and presentation of fire history patterns based on AVI data should be general, coarse-scale, and considered first approximations only.

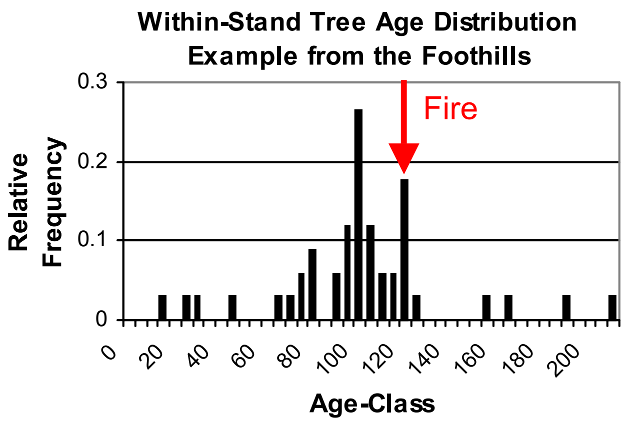
FMF Natural Disturbance Program Research

Quicknote No. 6 – January 2001

The "Even-Aged" Boreal Forest Myth

By: David W. Andison

The terms "even-aged" and "stand-replacing" are used routinely in reference to the boreal forest. Given the size and severity of forest fires and the tree species involved, this is understandable. However, it is a mistake to think of boreal stands as models of homogeneity, and forest fires as the cause of such patterns. On the contrary, so-called stand-replacing fires create significant levels of variability, or "heterogeneity" on the ground. For instance, in the 125 year-old foothills stand in the example below, about 10% of the trees survived the last fire – either as individuals, or clustered into "islands". This suggests that fire severity overall may have been high, but was spatially variable.



Similarly, fires injure trees and consume foliage, fine fuel, and forest floor biomass to different degrees over space. This helps to create conditions conducive to gradual rates of invasion after a fire. For instance, although the last stand replacing fire was 125 years ago in the example, recruitment took place for 100 years afterwards (although the majority took place in the first 25 years).

To be clear, the example above does not represent all boreal stands. There are many cases where the age-class distribution of individual stands is much narrower. For instance, fires in pure pine stands on flat ground are more *likely* to consume and kill material uniformly. On the other hand, *some* mixed-species stands exhibit age-class distributions that are truly multi-aged. The point is that almost all boreal stands exhibit some degree of age dispersion, either from survival, extended invasion periods, or both.

Age complexity is thus a "natural" pattern of the boreal landscape - partly from survivors, but mostly from gradual rates of invasion. This has some important implications. First, age complexity implies structural complexity. Within a single stand, there are likely many different types of habitat opportunities. Second, as Quicknote #5 discussed, this complexity partially explains why inventory stand ages are not very precise. Determining the date of the last stand-replacing fire can be tricky under these circumstances. Third, expectations of, and comparisons to "natural" stand functions and structure should be re-evaluated. We may have many sound reasons for wanting to create uniformly-aged stands across the entire landscape, but emulating natural patterns is not among them. Lastly, it means that the study of natural range of variation cannot stop at the landscape level. Fire frequencies and sizes may be important components of describing fire regimes, but an understanding of fire pattern is incomplete without an appreciation of *within*-fire patterns.

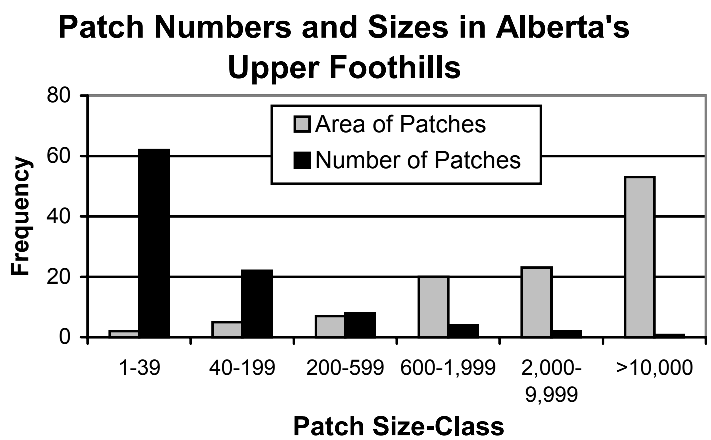
FMF Natural Disturbance Program Research

Quicknote No. 7 – March 2001

The Forest Fire "Event"

By: David W. Andison

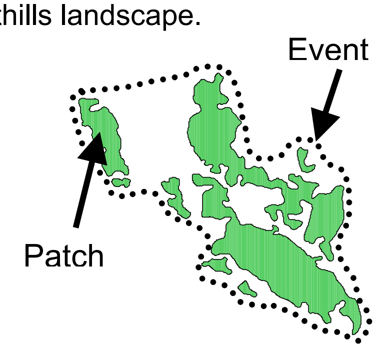
Fires in the boreal forest are commonly, and justifiably, referred to as "*events*". They tend to be memorable, occur over a very short period of time, and leave behind a mosaic of burnt and unburnt patches. Understanding the relationship between events and their constituent patches is essential if we are going to successfully integrate natural patterns into forest management.



Here is what we know so far. Most disturbance patches are very small. For instance, in the Upper Foothills, 62% of the young forest patches are less than 40 hectares in size, compared to 0.7% greater than 10,000 hectares. We also know that the large patches account for most of the land. Although few in number, young patches larger than 10,000 hectares cover over 50% of the Upper Foothills landscape.

We can also define an area relationship between patches and fire events. Since most events are composed of a number of disturbance patches, we expect large events to be even more prominent on the landscape. For instance, disturbance *patches* greater than 2,000 hectares occupy 71% of the Upper Foothills landscape, but disturbance *events* greater than 2,000 hectares occupy 90% of the Upper Foothills landscape.

Finally, we know that the undisturbed bits within fire event boundaries include both forested and non-forested patches. In fact, on the Upper Foothills landscape, non-forested patches contribute almost 40% of the undisturbed area within an event, despite the fact that only about 10% of the Upper Foothills landscape is non-forested. Hence, the relationship between disturbance patches and events is greatly influenced the number and size of non-forested patches.



As our understanding of natural patterns evolves, so should our response to that new knowledge. We have long been aware that most of the forest fires in the boreal forest are small, and that the largest fires cover most of the land. However, we now understand that fire "events" are clusters of different types and sizes of patches, the nature of which is largely dictated by the landscape context (*i.e.*, non-forested areas). This implies that we have to move beyond simple distributions of patch sizes, to the spatial arrangement of those patches, if we want to capture "natural" patterns.

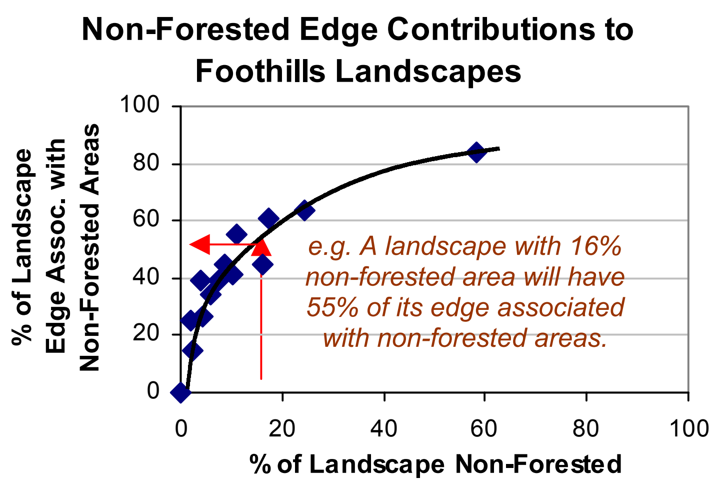
FMF Natural Disturbance Program Research

Quicknote No. 8 – May 2001

Are All Edges Created Equal?

By: David W. Andison

In order to help us describe and understand landscapes, we group similar types and sizes of vegetation into "patches". One of the more common ways of evaluating a landscape is through the amount and/or density of "edges" - the boundary zones between these patches. Edges can affect the flow of water, light, nutrients, and wildlife from one patch to another, and may even serve as unique habitat. The edge density of a landscape is easy to calculate, and we know more every day about how and where edges affect what species, and in what way. On the other hand, we know very little about landscape edge dynamics.



It is all too easy to think of edges in universal and simple terms; one much the same as another. It has also become common to think of edges in a negative context. In fact, natural landscapes in the Alberta Foothills are almost all dominated by *permanent* edges. If we define the patches in unmanaged landscapes using universal criteria, we find that most of the total edge is due to the boundary between forested and non-forested patches. This is particularly surprising given that the non-forested portion of a given landscape is only between 3-20% in most cases. In other words, non-forested patches are generating far more edge - proportionally - than expected. The explanation of course is that the shapes of non-forested patches are highly convoluted.

This discovery is very informative. First, it highlights the importance of non-forested areas on our landscapes. We tend to focus on upland, merchantable forest for both research and management, but clearly non-merchantable areas play a significant role in landscape dynamics. Second, it demonstrates that there are different types of edges on landscapes - presumably, with different functions. Third, the consistency of the area-to-edge ratio in the figure suggests that landscapes have intrinsic, predictable, levels of forest-to-forest edges. This information could be used as a landscape-level guide for management or monitoring purposes. And lastly, edge density assessments that do not differentiate between different types of edges don't tell the whole story.

FMF Natural Disturbance Program Research

Quicknote No. 9 – July 2001

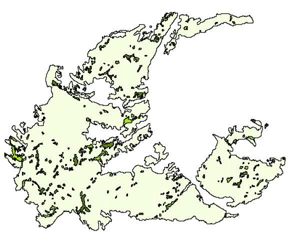
The Mystery of Patch Shape

By: David W. Andison

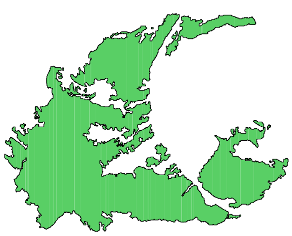
"Shape" is the relationship of the length of the perimeter of a patch relative to its area. Circles are the simplest shapes and thus have a "shape index" of one. As patches become more convoluted, the amount of perimeter per area increases, and the shape index climbs. In the figure below, the shape index of 5.8 refers to a perimeter length 5.8 times longer than that required for a circle (of the same number of hectares).

Many landscape pattern studies suggest that patch shape increases as patch size increases – often dramatically. While this is generally true of Alberta, interpreting this assertion is not as simple as it would seem. For example, pattern software may not differentiate between *perimeter* and *edge*. "Edges" include the exterior perimeter of a patch, plus all of the boundaries of internal features such as islands. So in the fire example below, a shape index of 10.2 is computed using all (internal and external) edges. Yet, when the edges of island remnants are eliminated from the calculation, the shape index is reduced to 5.8. In other words, islands account for almost half of the edges in this particular fire.

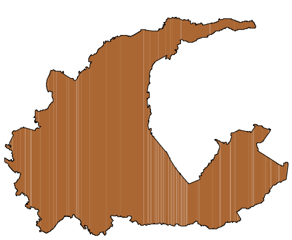
Patches with Islands
Shape = 10.2



Patches Alone
Shape = 5.8



Event Area
Shape = 2.2



When all internal complexity (in the form of peninsulas and corridors) is dissolved, the shape of the gross fire event area (see Quicknote #7) is 2.2. In fact, the shape of fire events (as opposed to patches) is actually quite consistent. For 22 sample fires in the foothills of Alberta ranging in size from 28 to 18,000 ha, shape index averages 2.4 and is not related to disturbance size. The sample fire used here is about 8,900 ha.

From an ecological point of view, this further supports the notion that there are different types of edges on a "natural" landscape (see Quicknote #8). It is quite possible that island and corridor edges function differently than do perimeter edges.

From a practical point of view, this finding suggests that forest management and monitoring should be planning for, and differentiating between different types of edges, and nested levels of complexity. Fortunately, the relationship between event shapes and patch shapes facilitates a logical progression. Event area shapes are consistently simple, meaning both large and small disturbance events can be designed strategically. At operational scales, the perimeter of individual patch shapes within an event become more complex as patch size increases. At even finer scales, the amount of internal edge increases with patch size as the number and amount of residual islands in each patch increases. The trick is to understand, and distinguish between the different expressions of "shape", and make sure comparisons to baseline data are equitable.

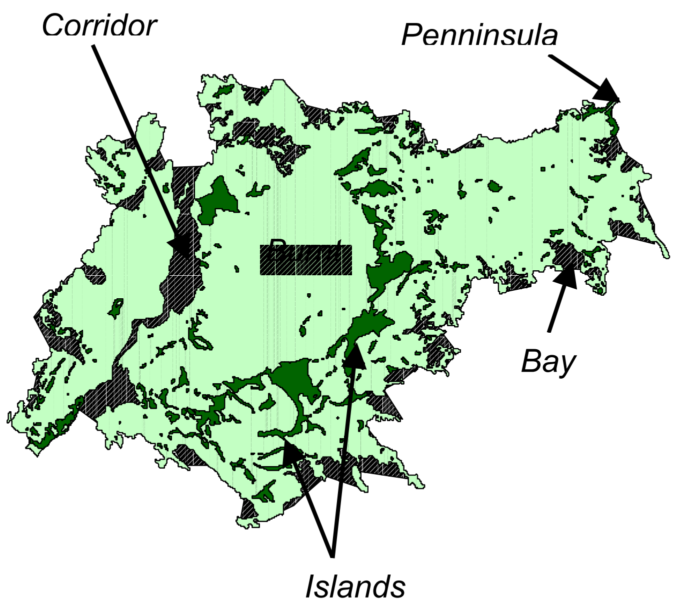
FMF Natural Disturbance Program Research

Quicknote No. 10 – September 2001

Morphology of a Forest Fire

By: David W. Andison

It is easy to think of a forest fire as a continuously disturbed area scattered with a few residual individuals and clumps of unburnt material. Reality is much more complex – and variable. We already know that fire events usually involve numerous individual burnt patches (see Quicknote #7). The type, number, size, and spatial arrangement of unburnt patches within each disturbance event are equally important "natural pattern" considerations. In fact, on average, almost 1/3 of each fire event in the Alberta foothills is at least partially unburnt.



There are two major types of residual material within a fire; "island" and "matrix". Matrix residual patches such as corridors, bays, and peninsulas are within the greater event area, but are still physically connected to the surrounding forest matrix. Matrix residuals account for between zero and almost 50% of the total area of a fire event, and averages 22%. Matrix residuals include both forested and non-forested areas.

Island residual patches are physically disconnected from the matrix, and thus completely surrounded by disturbed forest. Island residuals account for anywhere from 0-20% of the area of a fire event, averaging about 9%.

The distinction between matrix and island residual material is a subtle one. For instance, if the fire shown above burned for even one more day, it is not difficult to see how the corridor, or any number of bays could lead to the creation of islands. In fact, the distinction between islands and interior matrix residual patches is largely a classification and analytical artefact. Ecologically, they both amount to much the same thing; internal heterogeneity.

This conceptual model of a forest fire is quite valuable. For instance, restricting ourselves to the question of island residuals would significantly underestimate the actual area of residual material in a fire event. Islands account for only 9% of the event area, while the total area in event residuals is almost 32%. The close relationship between island and matrix residual material also suggests that all forms of "residuals" should be considered as a package when planning cultural disturbance events. Finally, this model demonstrates highly variable mortality within so-called "stand-replacing" fire events, further supporting the notion of age complexity in the boreal forest (see Quicknote #6).

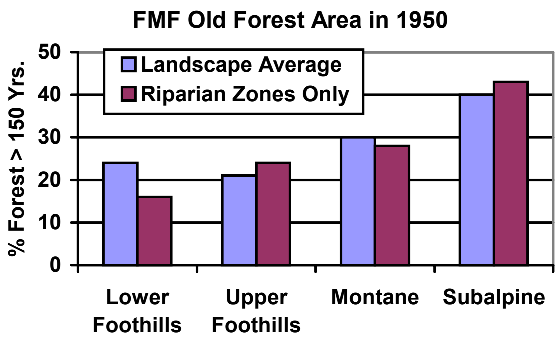
FMF Natural Disturbance Program Research

Quicknote No. 11 – November 2001

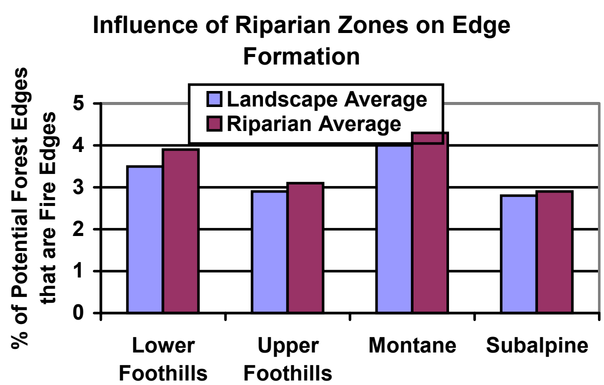
Do Riparian Zones Influence Landscape Burning Patterns?

By: David W. Andison

Not really. While we know that fine-scale landscape features can and do influence fire behaviour at very coarse scales, the simple presence or absence of a riparian zone does not appear to be one of them. For example, the amount of older forest in each of the four major landscapes on the Foothills Model Forest in 1950 is not significantly greater in riparian zones compared to the rest of the landscape. If riparian zones are less likely to burn, we would expect to see greater percentages of old forest in riparian zones (relative to the upland part of the landscape) at any one point in time. As it is, there actually *less* old forest in riparian zones in two out of the four landscapes.



Similarly, if riparian zones are less likely to burn, they may simply stop a fire from advancing at that point. In other words, we would expect to see more fire edges associated with riparian zones. However, while the tendency of riparian zones to be associated with fire edges is marginally higher than that of the rest of the landscape, the differences are not significant.



Other, more complex tests are possible, but overall, we found no evidence to suggest that over very large areas, and many decades of burning, the presence or absence of a riparian zone affects fire patterns. However, this does mean that riparian zones do not influence local fire *event* burning patterns. There may be local-level fuel influences, or fire type or severity differences that landscape overviews averaged out. For example, perhaps riparian zones associated with steep banks and higher stream orders are highly associated with fire edges on smaller, low intensity fires.

Future Quicknotes and research reports will address these finer-scale riparian issues, but in the meantime, these findings represent some important lessons. First and foremost, it dispels the notion that riparian zones are commonly protected from fire. At landscape scales, they burn as often as upland forests in west-central Alberta. Second, it underlines the importance of looking at questions at several scales. Seldom is a single study of disturbance pattern, at a single scale, conclusive. Finally, it highlights the difficulty of using general-level rules to achieve natural pattern emulation goals. Solutions are more likely to be associated with local-level opportunities.

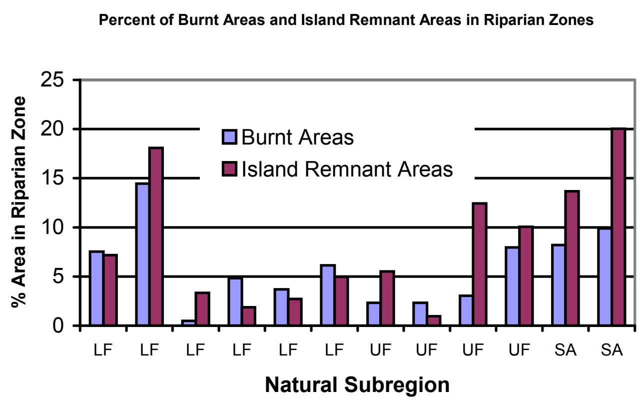
FMF Natural Disturbance Program Research

Quicknote No. 12 – January 2002

Do Riparian Zones Influence Local Burning Patterns?

By: David W. Andison and Kris McCleary

To a limited degree, but in very specific ways. In general, the tendency of residual island remnants to form at or near riparian zones is slightly higher compared to the upland parts of fires. Field sampling demonstrated that 15% of riparian zones had higher than expected levels of surviving "veterans" from the last forest fire. Similarly, our island remnants study found that the average percent of island remnant area in riparian zones was 8.5%, compared to an average of 5.9% of the total burnt area in riparian zones.



However, it is the details that are truly informative. For example, we found that the tendency to form islands in riparian zones is very weak in topographically simple landscapes such as the Lower Foothills (LF in the adjacent Figure), relative to more complex landscapes such as the Upper Foothills (UF) and Subalpine (SA). We also found that island remnants are more likely to form in riparian zones within fires associated with less non-forested land. Finally, the riparian sites that are most likely to form islands are wetter, on wider streams and rivers, and associated with wider riparian zones.

None of these details are particularly surprising. However, what may be surprising is that each of these relationships is a relatively weak one. For example, the amount of variation in the island remnant data can be seen clearly in the Figure above. Nor did we find any relationship between islands forming in riparian zones, and slope, vegetation type or density, or the Rosgen stream classification. In other words, this means that local fire weather conditions are in all likelihood the main variables determining the fate of riparian zones when a fire burns through.

There are several significant conclusions here. First, the impact of the presence or absence of a riparian zone on the behaviour of fire is a fine-scale relationship, and represent local-level (management) opportunities. Recall that in Quicknote #11 we found very little evidence to suggest that coarse-scale variables were relevant. Second, any given riparian site on the FMF burns *almost* as often as their upland counterparts. No evidence was found to suggest that riparian zones serve as fire "refugia" from repeated burning, only that there are sites somewhat more or less likely to burn than others. Finally, the ubiquitous nature of fire in riparian zones suggests that disturbance is a necessary element of the terrestrial part of riparian ecosystems. Thus, removing disturbance from these systems may have significant ecological implications.

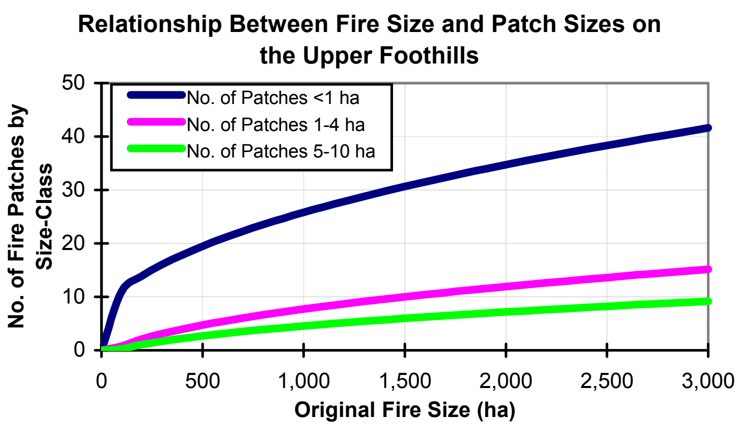
FMF Natural Disturbance Program Research

Quicknote No. 13 – March 2002

Don't Forget the Wee Ones

By: David W. Andison

It is common knowledge that large fires dominate northern landscapes right across Canada. However, very small natural disturbance patches are still quite abundant. For example, according to our stand origin data, 62% of the youngest forest patches in the Upper Foothills landscape are less than 40 hectares in size (see Quicknote #7). However, we have reason to suspect that even these estimates grossly underestimate the actual number of very small natural disturbance patches. Consider, for example, that small disturbance patches would be extremely difficult to identify using aerial photographs taken several decades after the event. Nor are fire data records reliable since (until recently) they tend to ignore smaller fires, and map only gross fire boundaries. Even modern-day estimates of fire size distributions are biased due to more effective control of small and intermediate-sized fires.



Alternatively, it is possible to reconstruct a *likely* patch size distribution using historical fire data. Recall from Quicknote #4 that disturbance events are composed of a number of individual patches. By using data from 25 historical fires in the Alberta Foothills, it is possible to estimate the relationship between fire event size and patch sizes. For example, in the adjacent figure, a 1,000 hectare fire has (on average) 27 patches less than 1 hectare in size, 8 patches between 1-4 hectares, and 4 patches between 5-10 hectares. By applying these relationships to the frequency of large fire events (for which we have very good data), we can recreate a probable disturbance patch size distribution. Based on these analyses, we found that the *minimum* number of disturbance patches less than 40 hectares in size in the Upper Foothills was 90% (as opposed to 62% from the stand origin data), and a more likely scenario results in 94%.

Our findings are not particularly surprising, but raise several important issues. First, as we have concluded in other Quicknotes, northern forest landscapes are "naturally" more complex than we may be assuming. This analysis suggests that for every disturbance patch greater than 40 hectares in size (some of which are tens of thousands of hectares, mind you), there are between 10-15 patches *smaller* than 40 hectares. Second, although we are beginning to do a laudable job of creating larger, more complex cultural disturbances, we should consider means of representing very small disturbance patches as well. Finally, it is clear that even highly accurate stand-origin maps may not pick up very small patches of different-aged forest. Recall that our accuracy level for the FMF stand origin map was about 80%. It is reasonable to presume that one reason it was not higher is that some small patches of younger forest were mistaken for stand-level heterogeneity.

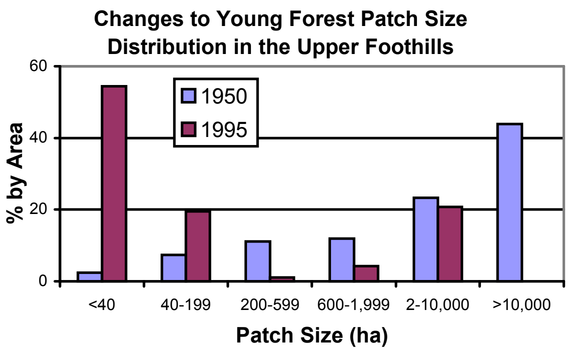
FMF Natural Disturbance Program Research

Quicknote No. 14 – May 2002

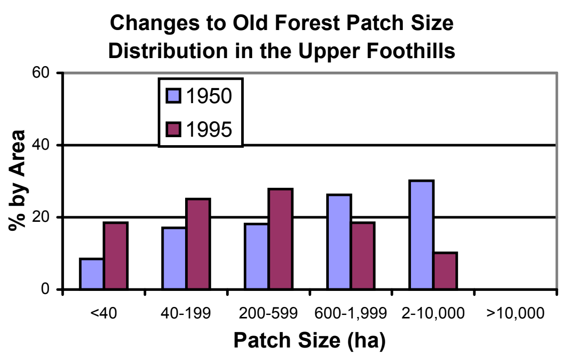
What's the Deal with "Fragmentation"?

By: David W. Andison

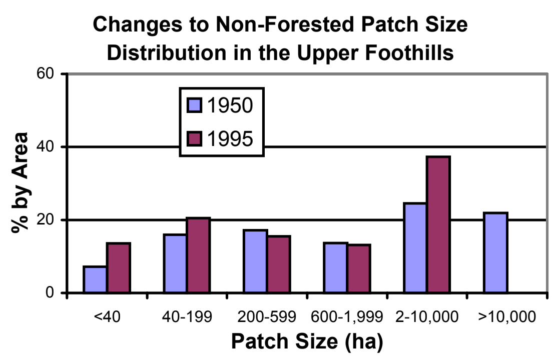
One of the most prominent changes to disturbance patterns in boreal forests over the last 50 years has been a shift in disturbance sizes. For example, in 1950 - prior to harvesting and fire control activities – about 2/3 of the young forest in the Upper Foothills area of the FMF was in patches larger than 2,000 hectares, and over 40% larger than 10,000 hectares. In sharp contrast, over half of the young forest on the same landscape in 1995 was in patches less than 40 hectares. In other words, disturbance sizes have declined tremendously over the last 50 years.



There are other, related changes to consider as well. For instance, there has also been a shift in the patch size distribution of older forest. In 1950, about 30% of older forest in the Upper Foothills was in patches larger than 2,000 hectares, compared to only 10% in 1995. The percent of old forest area in patches less than 40 hectares grew from 8% to 18% over the same period.



A similar, but less striking pattern can be seen in the patch size distribution of non-forested areas. Between 1950 and 1995, the percent of non-forested areas in patches greater than 2,000 hectares dropped from 46% to 37%, and the area in non-forested patches less than 40 hectares increased from 7% to 14%.



The patterns discussed here are classic, and logical, indicators of "fragmentation". The shift towards smaller patches of old forest is occurring because our dominant disturbance activity (i.e.,harvesting) is limited to older forest. Since we have been harvesting in such small patches, this can only result in a decline in the patch sizes of older forest. However, the results also strongly suggest that harvesting is not the only cultural activity causing fragmentation. The fact that non-forested (i.e., non-commercial) patches are declining in size can only mean that other cultural disturbance activities (such as road or seismic line building, or land clearing or conversion) are having an impact. In the end, although managing the sizes of harvest areas is important, it is our *cumulative* disturbance activities that are creating fragmented forest patterns and habitat.

FMF Natural Disturbance Program Research

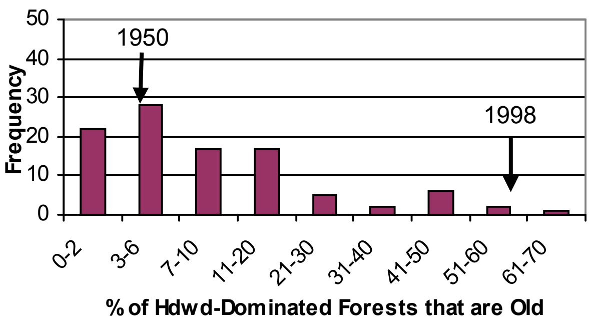
Quicknote No. 15 – July 2002

How Much Old Growth is "Natural"?

By: David W. Andison

We know that boreal landscapes are highly dynamic. This means that the amount of old forest on a given landscape is constantly changing – sometimes dramatically so. For instance, a landscape simulation exercise determined that between zero and 70% of hardwood-dominated forests in the (240,000 ha) Lower Foothills landscape of the Weldwood FMA were older than 120 years of age historically. This wide range is not surprising given local fire activity. The average fire cycle of the Lower Foothills is 65-75 years (Quicknote #1), and large fires can consume virtually all forest across tens of thousands of hectares (Quicknote #7). *(For the sake of argument, I assume here that "old growth" hardwood is anything >120 years)*.

Estimated Historical Frequency of Old Hardwood-Dominated Stands in the Lower Foothills on the Weldwood FMA



The problem is how to interpret this knowledge. In 1950, 4% of hardwood forests were older than 120 years of age, and in 1998 the area of old hardwood was 58%. Which number is more "natural"? On one hand, at any one point in time, both are within the natural range and thus both are *possibilities*. Using this logic one could argue for any number between zero and 70%. On the other hand, there is a much greater chance (historically) of 4% occurring than 58%, so 4% may be a more natural number.

One could also argue that *any* single percentage of old growth is irrelevant. Spatially, amounts of old growth vary from one landscape to the next. In fact, over very large areas we should expect the distribution of the percent of old hardwood on similar-sized Lower Foothills landscapes to resemble that in the figure. In the same way, on any single landscape, amounts of old growth will vary from one year or decade to the next – again in a distribution similar to that shown in the figure above.

Which interpretation is the right one? All of them. The amount of old hardwood on a Lower Foothills landscape, *at any given point in time* is "natural" if it is somewhere between 0 and 70% (in this case). Furthermore, temporally, the amount of old hardwood varies according to the distribution noted above. This means that over time, the 4% noted in 1950 will occur often, while the 58% noted in 1998 will be relatively rare. There will even be times when virtually no old growth exists. The same logic is applied to spatial distributions of old growth, which will also generally follow the distribution noted above. In other words, at any one point in time, each Lower Foothills landscape is likely to have a different percent of old hardwood.

Thus, the use of a single number to represent an old growth – or any seral-stage - target is not the *wrong* answer, just an incomplete one. As demonstrated here, interpreting this and other NRV attributes is not a simple matter. Furthermore, if "natural" old growth dynamics are an important landscape objective, the concern should not be the lack of an incomplete answer today, but rather not looking towards a more complete one for tomorrow. Given the complexities of understanding and integrating NRV knowledge into planning and management, a phased approach to adopting natural patterns makes sense. However, in the end we must be mindful of our terminology. Setting static old growth targets is clearly not natural pattern "emulation", but *can be* a part of an ongoing natural pattern emulation strategy.

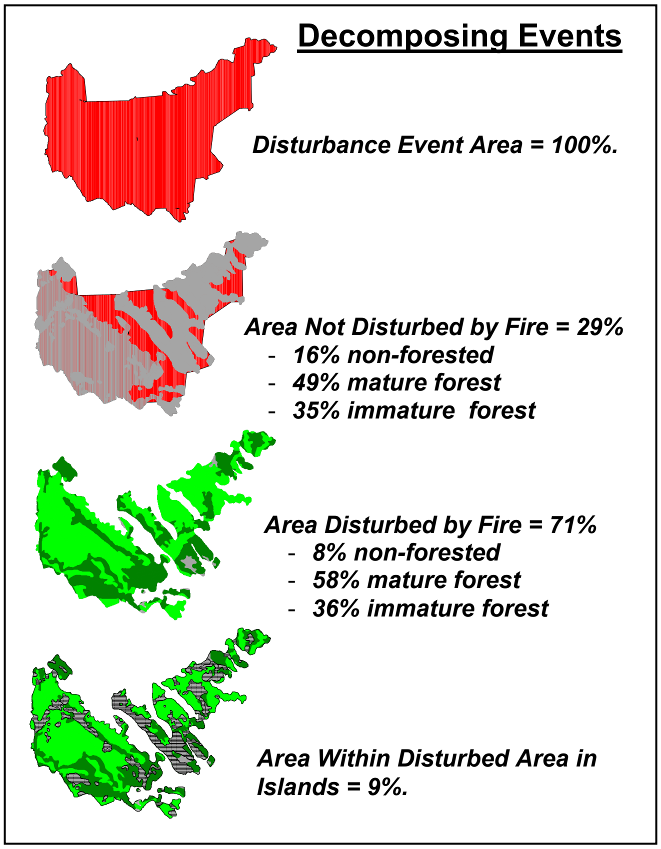
FMF Natural Disturbance Program Research

Quicknote No. 16 – September 2002

Four Ways of Knowing a Fire

By: David W. Andison

A forest fire can be described and understood in a variety of ways. Four possible perspectives are illustrated below using several of the FMF databases. A single rough outer boundary describes the "event" area (see Quicknote #7) similar to what one might find in a provincial fire database. Within the event area, a considerable amount of area is often not burnt. On foothills landscapes, this unburnt area accounts for 29% of the fire event area on average. Of this unburnt area, we found that approximately 16% is non-forested, 49% is "mature" forest, and the other 35% is "immature" forest (Note that "mature" refers here to commercial viability defined by a minimum age of 75 years). Of the patches within an event that *are* burnt by fire, about 8% are non-forested, 58% mature, and the other 36% immature on average. Finally, within burnt patches are small un-burnt island remnants, which account for another 9% of the fire event area on average.



While the average results depicted in the adjacent figure are 1) highly variable from one fire to the next, and 2) specific to west-central Alberta landscapes, they illustrate several important points. First, while the proportion of disturbed mature forest is dominant in relative terms, it is small in absolute terms. In our sample, on average, only 37% of the event area is composed of burnt forest older than 75 years of age (58% of 71%, minus 4% in islands).

On the other hand, disturbed immature forest accounts for about 22% of an event (36% of 71%, minus 4½% in islands), on average, and disturbed non-forested another 4% (8% of 71%, minus 1½ % for islands). While "disturbing" young forest and non-forested areas is certainly challenging from the practical and economic perspectives, it is clearly a natural pattern, and presumably that pattern has relevant ecological functions.

It is also interesting that the composition of the area not disturbed differs from that of the area disturbed. For instance, non-forested areas account for 16% of the area not disturbed, but only 8% of the area disturbed. This suggests that fire may be selecting against non-forested fuel-types (at very broad scales). Similarly, the area of mature forest in the non-disturbed area is 49%, compared to 58% in the disturbed areas. In this case, the fires may be selecting in favour of older forests.

More generally, this comparison demonstrates the importance of choosing an appropriate way of describing disturbances. All legitimately describe a fire, but by changing the level of resolution or the classification system used to describe the elements of a fire, very different perceptions are generated. The most appropriate method depends on the questions being asked.

Natural Disturbance Program Quicknote #17

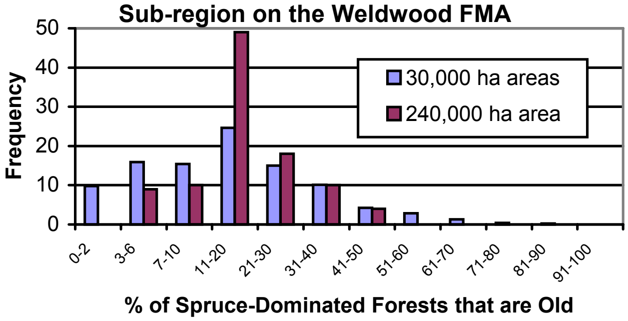
November 2002

By: David W. Andison

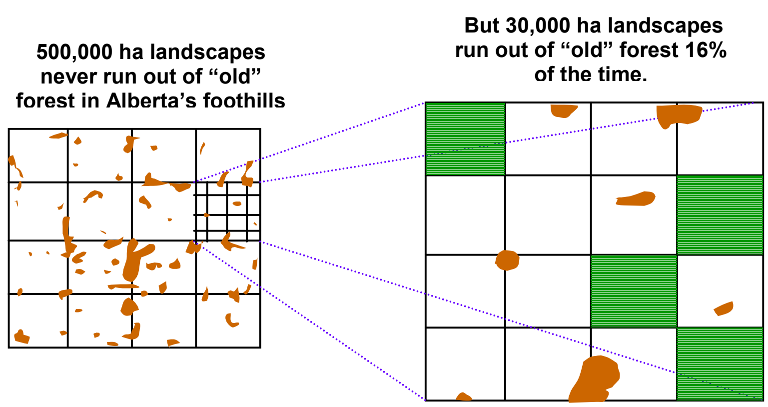
Defining Old Space

An understanding of old forest in the foothills of Alberta is incomplete without considering the question of spatial extent. From Quicknote #15 we know that old forest is highly dynamic over time. But we also know that old forest is dynamic acoss space as well. For instance, the percent of spurce-dominated old forest in the Subapline area of the Weldwood FMA range between zero and over 80% on 30,000 hectare landscapes. The same range for 240,000 hectare landscapes is about 4 to 50%. Furthermore, on 240,000 hectare landscapes there is a 50:50 chance the amount of spruce-dominated old forest is between 11-20%. This is almost twice the chances of 11-20% spruce-dominated old forest occurring on 30,000 hectare landscapes. In other words, the natural range of old forest becomes narrower and more predictable as spatial extent increases. It is not difficult to imagine that over several million hectares the historical range may be entirely within the 11-20% class.

Estimated Historical Frequency of Old Spruce-Dominated Stands in the Subalpine Sub-region on the Weldwood FMA



This relationship is not surprising. Both the location and size of forest fires are highly stochastic, and we already know that very large fires can and do occur. Fires in excess of 100,000 hectares could virtually eliminate all significant patches of old forest from small landscapes for many decades. However, the chances are far less likely of one or more fires depleting old forest on much larger landscapes. In the example below, it is obvious that unless old forest patches are distributed uniformly in space, as the size of the landscape decreases, the chances increase that one or more such landscapes have no old forest. Similarly, the chances of the smaller landscapes having very large percentages of old forest also increases.



These examples demonstrate well that having uniform levels of old forest everywhere is not only unrealistic but also historically unprecedented. As old forest blinks "off" over small landscapes for extended periods, there are always other small landscapes that will be dominated by old forest. Furthermore, it is not difficult to imagine that old forest functions optimally when it occurs as a highly variable range of sizes, shapes, locations, and adjacencies. The example also shows that averages are meaningless. The fact that the average percentage of old forest for 30,000 ha landscapes is identical to that of a 240,000 ha landscape is not a particularly valuable piece of information. However, the *range* around the average is more relevant.

In summary, there is no single scale at which old forest is best represented. Robust old forest management and monitoring strategies in the Alberta foothills should thus consider several spatial scales if they are meant to emulate or compare to a "natural" template. Lastly, it is important to keep in mind that this particular pattern is not unique to old forest. Although it served well as the example here, the link between higher variability and smaller spatial extents is evident for all seral-stages.

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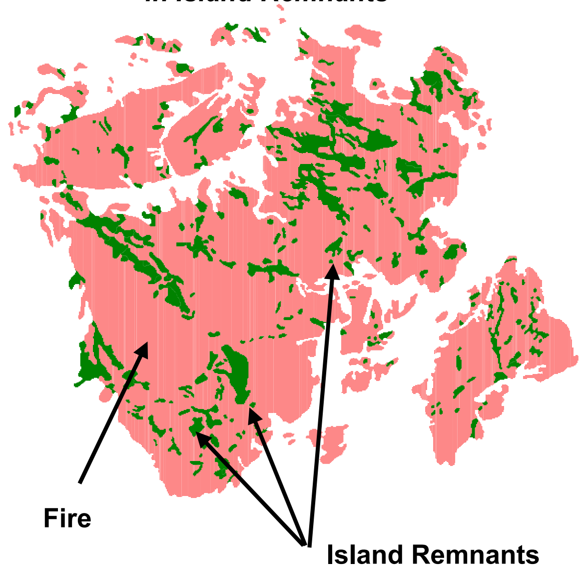
Natural Disturbance Program Quicknote #18

January 2003 *By: David W. Andison*

Surviving as an Island Remnant

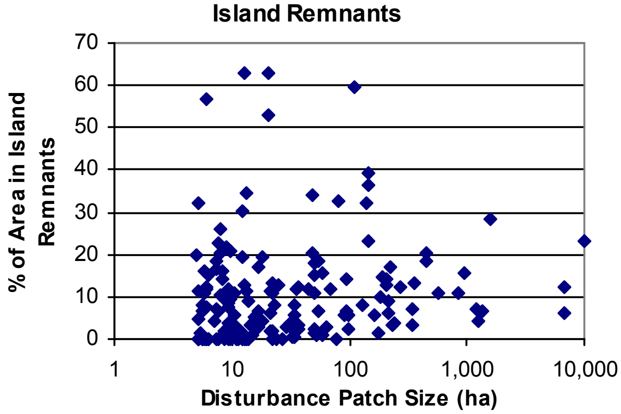
Within disturbed patches of so-called stand-replacing forest fires are areas where mortality is incomplete. The occurrence of such "island remnants" is common and accounts for a substantial portion of many natural fire events. In fact, on average, island remnants account for about 12% of every fire in west-central Alberta. Even more notable is the wide variation about this average. For example, of the 170 disturbance patches used in our analysis, 17% had no (i.e., 0%) island remnants, while 8% had greater than 30% of their gross area in island remnants. In fact, 3% of our sample patches had more than 50% of their area in island remnants. Another prominent pattern to note is that the area in island remnants is not associated with fire size in west-central Alberta. In other words, there is no evidence to suggest that larger fires have proportionally more area in island remnants.

681 ha. Fire With 76 ha. (11%) in Island Remnants



Neither the presence, nor the variation of island remnants is particularly surprising, and we have seen evidence of survival from fires elsewhere (see Quicknote #6). Fires in these forest types burn incompletely due to changes over time in wind and weather conditions, and changes over space in local topography and fuel-type. It is not difficult to imagine that during very hot dry periods, or through dense conifer-dominated forests, fires will burn fairly thoroughly. In the same way, through discontinuous fuel-types, or across complex topography, fires can burn at lower levels of intensity for extended periods creating a mosaic of mortality. In fact, our data show that island remnant areas *within* fires are less variable than *between* fires, supporting the notion that local burning conditions are significant factors.

Percent of Disturbance Patch Area in Island Remnants



What this means is that we must recognize both the presence, and the variation, of island remnants as relevant natural phenomena. For example, we know that island remnants function as habitat, cover, seed dispersal, and the opportunity for non-motile organisms to survive. It logically follows that the wide variability of island remnant area noted here is also ecologically relevant. In other words, the presence of those disturbances with little or even no residual material is just as critical (although perhaps in different ways) as those disturbance events with very high levels of residual islands. This is both a challenge and an opportunity for those wishing to include island remnant patterns into forest management planning systems.

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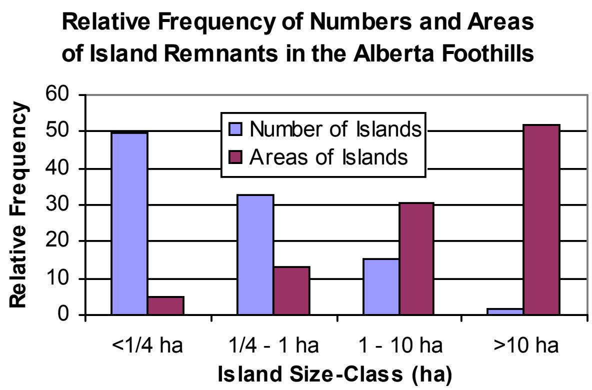
Natural Disturbance Program Quicknote #19

March 2003

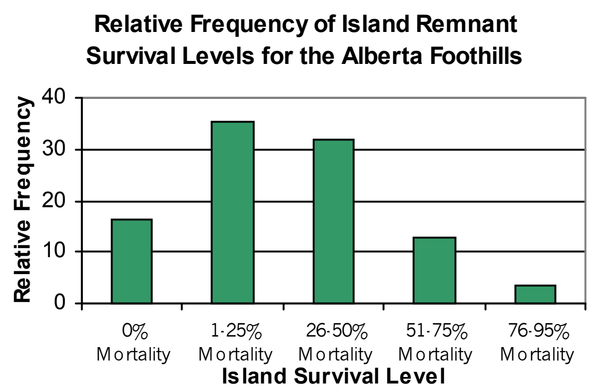
By: David W. Andison

Are all Islands Created Equal?

Residual island remnants come in a wide range of sizes, shapes, types, and configurations. Adopting the definition of an island as "*at least four clustered trees*", island remnant sizes range from 10 square meters to hundreds of hectares in west-central Alberta. And although very large islands are responsible for most of the area in island remnants, the vast majority of islands are very small. In fact, about half of all island remnants from historical fires in this area are less than ¼ of a hectare in size, and over 80% are smaller than one hectare. Islands larger than 10 hectares account for less than 2% of the numbers of islands, but over 50% of the area in islands. This happens due to the influence of a very small number of very large islands.



Survival levels within island remnants are also highly variable, and somewhat related to island size. Indeed, only 17% of island remnants in west-central Alberta survive forest fires with no internal mortality, and these islands tend to be smaller. Almost 2/3 of the island remnants experience between 1 – 50% mortality, and another 16% are heavily affected by fires (greater than 50% mortality). Higher mortality levels are also generally associated with larger islands.



These results are revealing in several different ways. For example, it is interesting that the patterns noted here are familiar ones. Although the proportions in each size-class differ, the shape of the island size distribution in the first figure is identical to those of both disturbance events and disturbance patches (see Quicknote #4, #7 and #13).

Also, while there is tremendous variation in the type and amount of residual material left within a fire, the interaction between size and mortality suggests that this variation is not necessarily all random. This relationship has been noted before (see Quicknote #10 and #18), and is further evidence of the structural and compositional complexity created by forest fires. Furthermore, it is important to remember these fine-scale patterns are in fact all "coarse-filter" attributes. Thus, the biological functions served by variations in the sizes and types of islands are not necessarily any less critical than those served by other coarse-filter attributes such as disturbance event sizes.

The last point to note is the large influence of 1) data resolution and 2) classification systems on observed patterns. For example, if one chose to define an island as "*at least 10 clustered trees*" (instead of four), the data summary in the first figure would change significantly. Similarly, areas with 76-95% mortality (from the second figure) may not even qualify as "residual", let alone as "island" in some mapping or interpretation systems. Thus, while the results presented here may or may not be unique to west-central Alberta, they are without a doubt unique to the chosen levels of resolution and rules of classification. Both factors are critical to keep in mind when measuring, comparing and planning for residual island materials.

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Natural Disturbance Program Quicknote #20

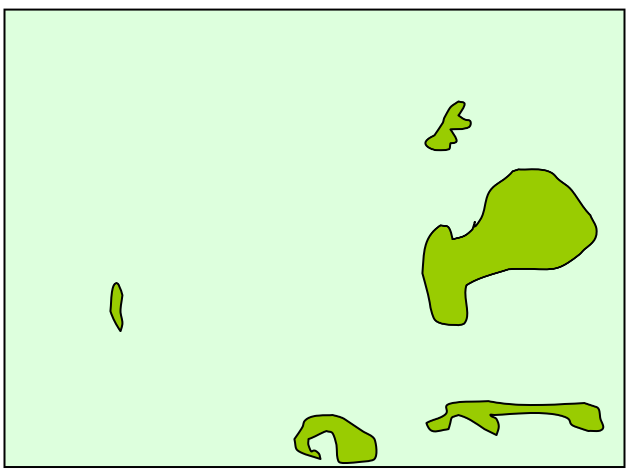
May 2003 *By: David W. Andison*

Old Growth……Islands?

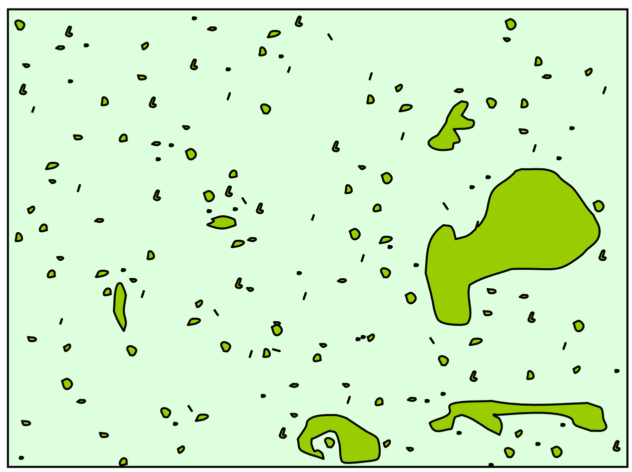
Why not? We tend to think of old growth only as a landscape-scale attribute. Traditional old growth concerns include total forest area (Quicknote #15) and the size and integrity of the largest patches (Quicknote #14). However, depending on how one defines "old growth", there may be much more to it.

We already know that forest fires in the Alberta foothills leave a large number of residual islands down to a fraction of a hectare in size (Quicknote #18). Island remnants represent a range of ages, but a portion of them will be old forest. If we assume the proportion of the area of old forest islands is approximately the same as the proportion of old forest area on a given landscape, most old forest patches are island remnants. In fact, between 92-98% of the total number of old forest patches in the foothills of Alberta are islands remnants (depending on the landscape). This translates into 10-15% of the total area of old forest accounted for by islands.

The impact of these islands on landscape pattern is striking. In the diagram below are two different images of a hypothetical, but conceptually accurate landscape. The image on the left shows only the old forest patches that would be visible from a stand origin or inventory map. The image on the right shows those same large patches, *plus* the average proportional density of old forest island remnants that would exist on that same landscape. Thus, while large patch old forest may be dynamic in time and space across large areas (Quicknote #17), island old forest is much more ubiquitous.



Landscape Showing Old Forest Patches



Landscape Showing Old Forest Patches - Including Islands

Obviously, island old forest will not share the same structural and functional characteristics as larger old forest patches since few islands, if any, have interior forest. However, at the very least they function as seed sources, "life-boat" refugia, and habitat of a different sort. And their prevalence across foothills landscapes suggests that these functions are historically important.

If we accept this expanded version of old forest, it challenges current old growth strategies to be more holistic. Such plans should recognize and include operational planning issues if they are going to truly reflect sustainability. It also means broadening our ideas about the form and function of residual island remnants. Presumably young islands function differently than do old ones. Lastly, this note reveals an interesting, yet logical intersection between two seemingly distinct natural pattern attributes.

For more information on this or other ND Quicknotes, please contact: Dr. David Andison, Bandaloop Landscape Ecosystem Services, Tel.: (604) 939 – 0830, Email: andison@bandaloop.ca, or visit www.fmf.ab.ca

Natural Disturbance Program Quicknote #21

July 2003

By: Pete Bothwell, Brian Amiro and Alan Westhaver

Burning Questions:
What is the Cumulative Effect of Different Natural Disturbances?

If the cumulative effect of man-caused disturbances is difficult to pinpoint, natural disturbances paint an even less clear picture. Unfortunately, the cumulative effects of natural disturbances on the Alberta foothills have not been substantially quantified, at least not independently. Recent work with the Foothills Model Forest, Jasper National Park and the Canadian Forest Service attempts to prod some of these relationships and begin to sort through the effects of each disturbance on the montane ecosystem.

We already know a few park management issues. Ungulate populations, especially elk, are very high. Recent fire return intervals, relative to historical estimates, are unnaturally low and yield abundant old growth forests. Consequently, forest pests such as bark beetles thrive in these environments, and shorter-living tree species such as aspen begin to disappear. Reasons for this are still unclear.

Aspen regeneration in a fenced plot burned in 1998.

Our experiment applied two fire intensities (high and low) to a lodgepole pine – grassland forest (with some patches of aspen) surrounding the Jasper airstrip. In each burn intensity, fenced and unfenced plots were established in both open and closed canopy forest.

What have we learned? For the low intensity fire, open pine forest tree mortality was greater than 90%, while closed canopy pine forest tree mortality was only 60%. Our results suggest this is primarily associated with tree crowns closer to the ground and a proportional increase in crown scorch in the open pine forest. This provides an excellent example of the subtle differences forest cover can make in post-fire stand structure. Interestingly, the effect of forest cover had almost no effect on forb and grass cover and diversity following the second year post-burn, and consequently problems with non-native invaders (weeds) have been avoided. While fire itself did not seem to have any influence on elk populations, fenced plots have provided very convincing evidence of the effect of herbivory on biomass accumulation and aspen regeneration, as seen in the picture above taken 3 years after a fire.

While few of our findings are particularly surprising, they begin to shed light on the complex interactions of the various natural disturbances, and the balance among them. Furthermore, management strategies that are targeted at very specific goals, such as wildlife habitat, can be perceived as man-caused disturbances of their own. Future work with the Foothills Model Forest will continue to quantify these relationships and follow the effects of fire severity and ungulate herbivory on vegetation dynamics.

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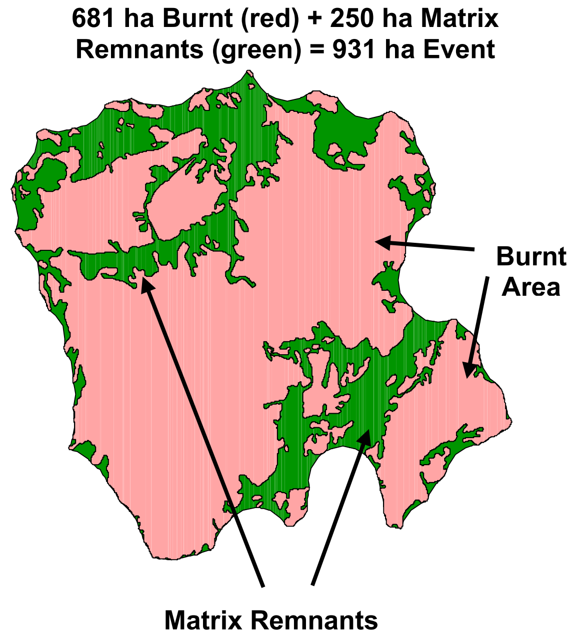
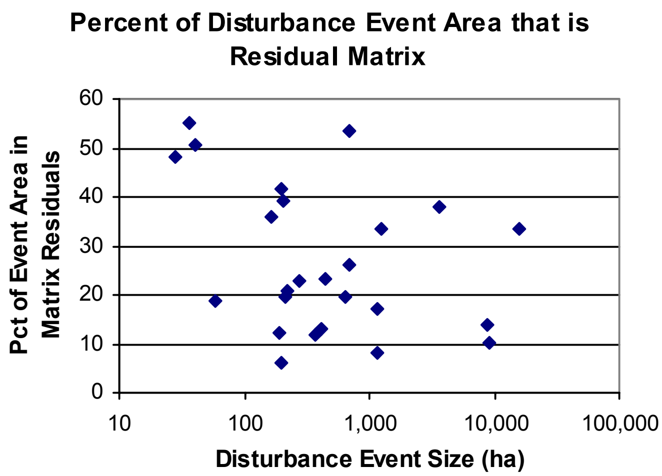
Natural Disturbance Program Quicknote #22

September 2003 *By: David W. Andison*

Surviving as (Surprise!) a Matrix Remnant

Most of the unburned residual forest within a fire is not in island remnants. Far more area within a fire survives as corridors that remain attached to the forest landscape matrix. In fact, in west-central Alberta, "*matrix remnants*" account for an average of 26% of disturbance event areas. In the 931 ha event shown in the adjacent figure, the burnt area covers 681 ha and the matrix remnants cover 250 ha. Thus, 27% of this fire event is in matrix remnants (representing about 35% of the burnt area). Recall from Quicknote #18 that an average of just 12% of the burnt area is accounted for by island remnants. Matrix remnants overall contribute three times as much area as do island remnants.





The patterns of residuals are otherwise very similar. For example, the percent of area in matrix remnants shows the same wide variation found in island remnant areas (see adjacent figure). Nor is there any relationship between the percentage of area in matrix remnants and either the size of the fire event, or the number of disturbed patches – both similar to relationships noted for island remnants (see Quicknote #18).

It is revealing to contrast island and matrix remnants from different perspectives. The differences are marginal from purely a pattern perspective. The presence or absence of one narrow strip of forest is often the deciding factor. Furthermore, it is unlikely that the fire behaviour tendencies that create island remnants are any different than those that create matrix remnants. In other words, remnants are remnants.

From a functional perspective, it is the difference between having spatially continuous "corridors" (as matrix) and spatially discontinuous "stepping stones" (as islands). It is *possible* that different collections of species prefer one or the other type of remnant, (although we have little direct evidence at this point), which would mean that the two types of residuals function slightly differently.

We also have to be aware that we have created an artificial division between island and matrix remnants because of our own methods of observation. Matrix remnants are logically described and understood at a slightly coarser spatial scale than island remnants. Consider that it is not possible to define matrix remnants without understanding and defining the disturbance event. Island remnants can be (and usually are) defined and described at only the disturbance patch scale. This is a crucial point worth considering. If we are unable to make the observational connection between island and matrix remnants, it is unlikely we will make either the pattern or functional connections.

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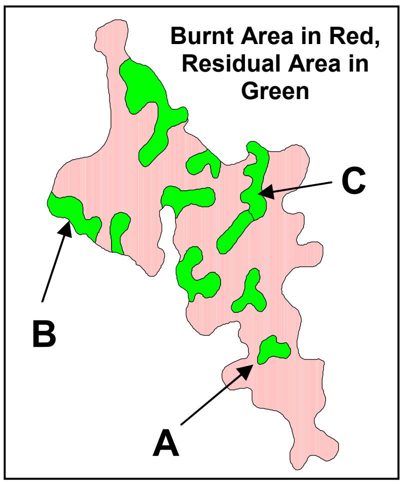
Natural Disturbance Program Quicknote #23

November 2003 **By: *David W. Andison***

Boundary Zones, or Islands with a Twist?

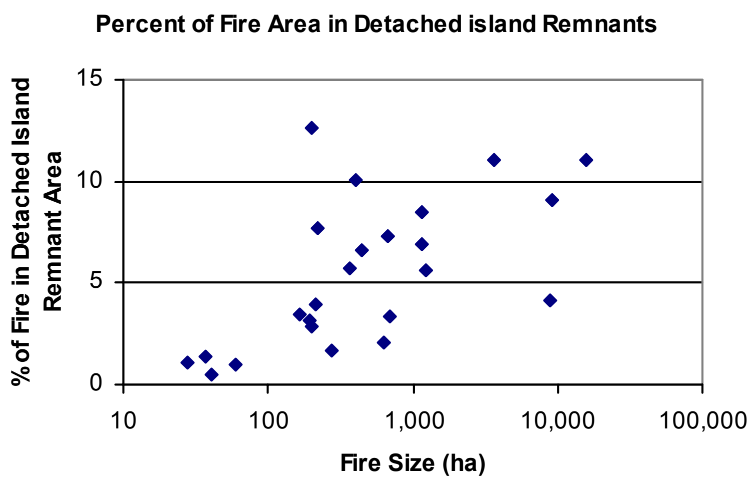
Island remnants have been previously defined as *areas within disturbance patches where mortality is incomplete* (Quicknote #18). However, island remnants are not necessarily always true islands. Many are still attached to the edge of the undisturbed forest. In fact, these '*edge*' islands account for more than half of the total island remnant area in historical fires of west-central Alberta. Given the nature of fire behaviour, this is not particularly surprising. One would expect to find lower fire intensity levels, and thus lower levels of severity near the edges of burnt patches.



One could argue that these so-called edge islands are not islands at all, but rather just partially burnt boundary zones, or even feathered edges. The problem is that the distinction is seldom obvious. For instance, in the adjacent example, residual patch A is completely detached from the fire edge, and thus clearly a true island remnant. Residual patch B shares much of its boundary with the that of the fire, and thus could be regarded as a boundary zone. However, the vast majority of the within-patch residuals that share some part of their perimeter with that of the fire, extend far into the disturbed area. For example, it would be difficult to argue that residual patch C (adjacent) is a true boundary zone.

Regardless of the terms used, the distinction – *based on objective criteria* - is worth exploring. For example, by isolating those islands that are fully detached (such as island A, adjacent), a slight trend of increasing island area with increasing fire size is evident (see Figure below). However, note the percentages in this Figure (y-axis) are about half of those for all island remnants combined in Quicknote #18.

The distinction between detached and edge islands provides some valuable new insight into the nature of residual patterns. For example, we now know that at least half of all within-patch residual material is located adjacent to the edge of the disturbance. This suggests that boundary zones of intermediate levels of mortality do in fact exist within forest fires in this part of Alberta. However, these areas are spatially disconnected, and have convoluted shapes that do not always follow the fire boundaries (and thus are more accurately denoted here as 'edge islands').



Perhaps the most valuable lesson is the importance of clarity and consistency of terms. Unburnt residuals exist in several different physical forms. There are '*edge*' islands, '*detached*' islands, and even different types of '*matrix remnants*' between disturbance patches (from Quicknote #22). By overlooking these distrinctions or using terms interchangably, it is not difficult to imagine that communication becomes difficult, which in turn inhibits education and integration. Not only do the areal contributions of each type of residual vary, but the likely mechanisms for integrating each type of residual into operational reality will differ as well.

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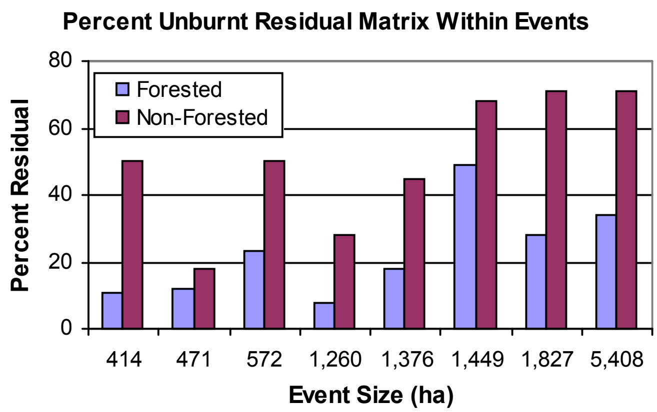
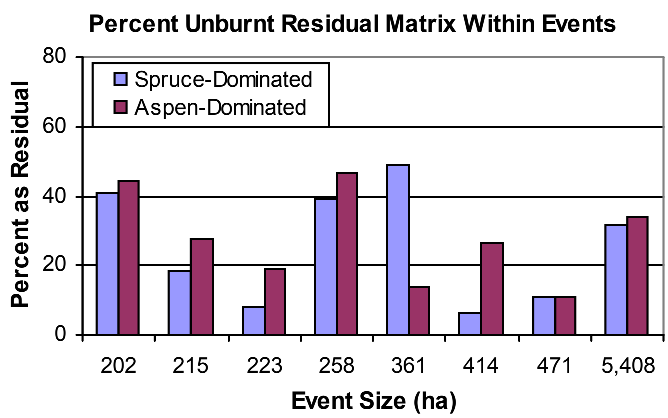
January 2004 *By: David W. Andison*

Does "Fuel-Type" Influence Fire Event Patterns?

Sometimes. For example, the distinction between forested (ie, any area with trees) and naturally non-forested areas (ie, scrub, bog, brush, and grass) is a critical one. Forested "matrix residuals" (or non-island residuals - see Quicknote #22) account for about 25% of the total forested area of a disturbance event, while non-forested matrix residuals account for about 50% of the total non-forested area within an event. In other words, the probability of a forested area burning within a fire event in west-central Alberta is about twice that of a non-forested area. Furthermore, although highly variable from one fire to another (see adjacent figure) all events had higher relative levels of residuals in non-forested areas.



However, a much weaker relationship is found between the probability of burning and dominant tree species. Hardwood-leading areas demonstrate only a slightly lower probability of burning than either spruce or pine-leading areas, based on matrix residual levels. Nor is this relationship consistent between events (see figure below).



Overall, there is little doubt that the presence of non-forested (but vegetated) areas influences fire event patterns. However, beyond that, the role of vegetation, or fuel-type, as an influence on the average fire pattern diminishes sharply.

This is seemingly in contrast to a considerable body of evidence that suggests that species composition is a critical factor influencing fire behaviour. In fact, this may very well be true, but in *relative* terms, the influence of species composition likely fluctuates. Fire event patterns are simply expressions of the relative influence of the full range of fire behaviour phenomena over time and space. It is not difficult to imagine that fires burning during very extreme fire weather conditions will respond to changes in tree species very differently than one burning under moderate fire weather conditions. So in fact, fire weather influences may often restrict the influence of species composition within a fire, while at other times, species composition may be a more dominant influence. The wide variation found in residual matrix patterns between fires in our data supports the idea that external phenomena are important factors in determining fire patterns. Even the relationship between the probabilities of forested and non-forested areas burning is highly variable between events.

In the end, these findings say more about the scale at which patterns exists than the degree to which they do. The fact that there is too much variation between fires to detect strong residual pattern "signals" suggests that understanding, and ultimately capturing, the variation in residual patterns *between* fires is at least as important as capturing residual patterns *within* fires. This also demonstrates the peril of representing within-event residual patterns by single fires, averages, or a single convention.

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foothills MODEL FOREST
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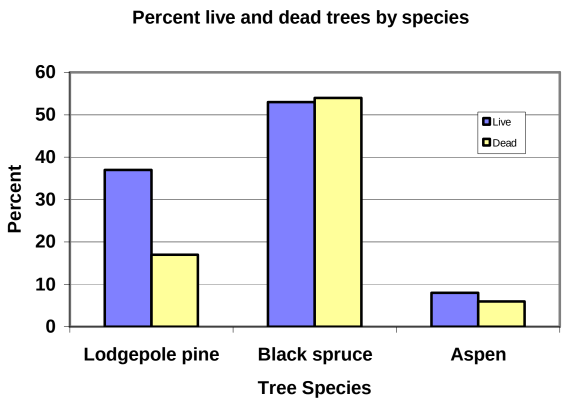
Natural Disturbance Program Quicknote #25

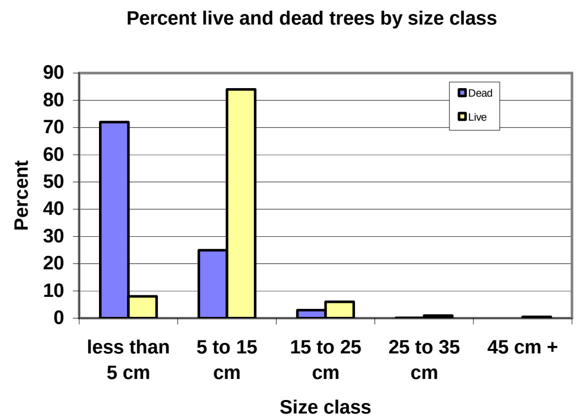
May 2005 By: Kris McCleary and David Andison

What happens after the fire?

Considerable effort has gone into describing natural disturbance patterns at landscape and meso scales. And while they are an important part of the natural disturbance pattern puzzle, the puzzle is incomplete without information on patterns at the stand scale. In this Quicknote, we will look at what we know about natural disturbance patterns in stands.

The first logical question is "what survives the fire?" Are certain species more likely to survive? Are larger trees more likely to survive? We found that Lodgepole pine tended to survive fire. We also found that larger trees are more likely to survive but that location (riparian or upland) had no effect.





The next logical question is "what happens to these trees that survive?" We know from the Virginia Hills and Dogrib Fires that **coarse woody debris recruitment is slow**. In the Dogrib Fire, only 8% of the CWD we sampled was created within 2 years of the fire and in the Virginia Hills, only 16% of the CWD we sampled was created within 3 years of the fire. There appears to be no relationship between CWD recruitment and decay class or size. However, we do know that CWD generated after a fire is likely to be suspended off the ground.

Post fire residual material patterns provide another piece of the puzzle in the study of natural patterns. We have excellent information on landscape and meso scale disturbance patterns and now we can complement that with an understanding of patterns at the stand scale.

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Natural Disturbance Program Quicknote #26

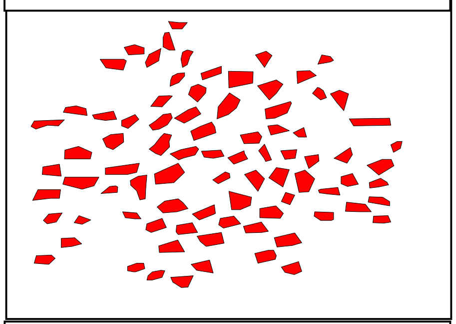
May 2004 *By: David W. Andison*

Paying Attention to "Negative Space"

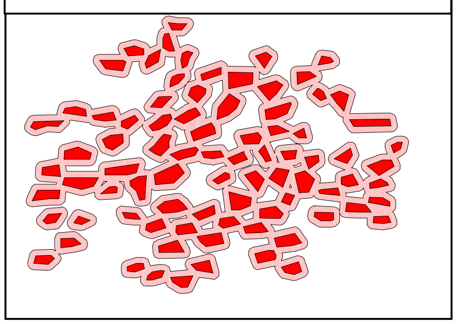
Considerable effort has gone into descriptions of the sizes, shapes, and configurations of natural disturbances, and the ecological consequences of those events. However, it is important to differentiate between the ecological relevance of disturbance patterns in and of themselves, and the critical role they play in modifying the landscape mosaic. For example, in the two disturbance scenarios illustrated below, the size and spatial distribution of the disturbance patches are very different, although the total area disturbed is identical. The pattern on the left (scenario A) depicts a dispersed (or "fragmented") pattern of regularly sized patches, while the one on the right (Scenario B) represents a ("natural") cluster of variously sized disturbance patches.

Disturbance Scenario A

2,400 ha disturbed (11% by area)

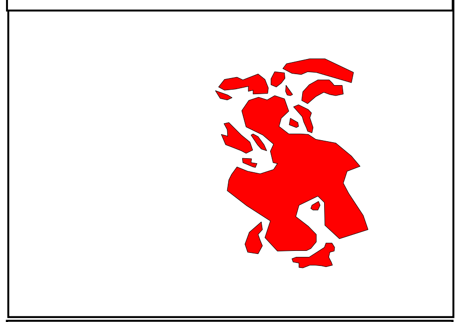


8,000 ha buffer (36% by area)

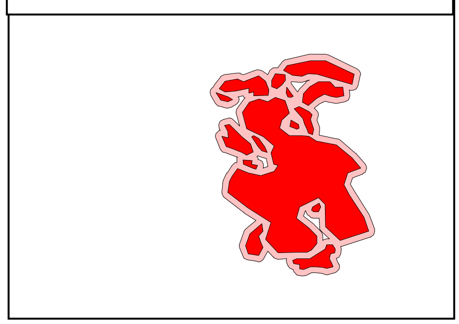


Disturbance Scenario B

2,400 ha disturbed (11% by area)



3,900 ha buffer (18% by area)



The direct, local influence of the disturbance pattern on key ecological attributes such as habitat, refugia, and seed dispersal for each scenario will be quite different. These relate to the "positive space" of the disturbance pattern – where and how large the disturbed areas and residuals are (see Quicknotes 7, 10, 18, and 22). These are also the disturbance attributes most often studied and described.

However, disturbance pattern also influences the landscape pattern – or the "negative space". For instance, a 250m buffer imposed on scenario A covers about 36% of the landscape, compared to only 18% for the same buffer on scenario B. Assuming that the distance to a disturbed edge is an ecologically relevant attribute, clearly a dispersed disturbance pattern impacts far more area of a given landscape than a clustered pattern. If we had measured the total size of the undisturbed patches of the landscape in the two scenarios, the differences would be even more pronounced. Thus, one of the primary functions of disturbance patterns is also to maintain overall landscape integrity – specifically, in this case, by minimizing impacts on the rest of the landscape.

Appreciating the duel role of disturbance patterns is critical if we hope to take full advantage of natural patterns in forest management. The danger of focusing on only the *positive space* aspects of disturbance is evident in the areas of the landscape that are fragmented (see Quicknote 14). It is also yet another example of the cross-scalar, complex nature of dealing with patterns. The good news is that patterns can be easily quantified, meaning that it is entirely possible to capture this complexity with the appropriate combination of indicators.

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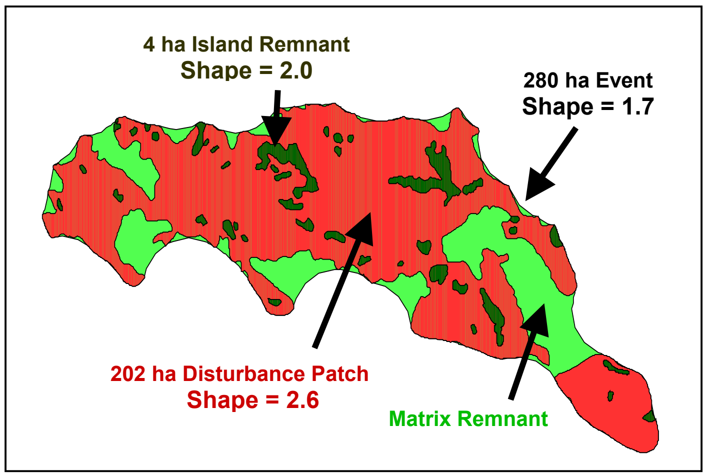
Natural Disturbance Program Quicknote #27

July 2004 *By: David W. Andison*

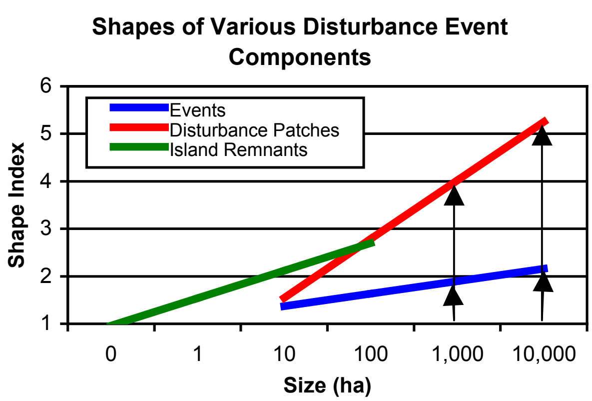
The Shapes of Things to Come

Different parts of forest fires in west-central Alberta have different shapes. Disturbed patches tend to be highly convoluted, while fire events (Quicknote #7) have very simple shapes. For example, the figure below depicts a typical fire event from west-central Alberta, with disturbance patches shown in red, and matrix remnants (Quicknote #22) in light green. In this case, the “shape index” (Quicknote #9) of the largest disturbance patch is 2.6, but the 280 ha event polygon (including all matrix remnants and disturbance patches) has a shape index of just 1.7. In other words, the perimeter of the disturbance event is 1.7 times longer than it would be for a 280 ha circle.



Surprisingly, given their size, island remnants are the most convoluted polygons within forest fires. For example, a 10 ha island remnant has the same shape index as a 30 ha disturbance patch, or a 6,000 ha event.

Common to all polygons is the fact that shape becomes more complex as size increases, although to different degrees. For example, a 1,000 ha disturbance patch has about twice as much perimeter as a 1,000 ha event (shape index of 1.9 and 4.0 respectively – see figure below). However, a 10,000 ha disturbance patch has 2 ½ times as much edge as a 10,000 ha event (5.3 versus 2.1 respectively).



These observations raise some interesting questions. For example, why are island remnant shapes so different than those of disturbance patches, given that they are both direct spatial products of forest fires? The higher complexity of island shapes may be a result of an elevated response to fine-scale shifts in fuel-type, fire weather or topography. If this is true, it suggests that islands are created by a slightly different combination of factors than are fire edges.

Similarly, why do disturbance patches become significantly more convoluted as they increase in size? Since there is no parallel increase in either island remnant or matrix remnant areas (Quicknotes #18, #22), this phenomenon may be related to an increase in the range of fire intensity associated with larger fires. If this is true, it means that large fires are influenced by a slightly different combination of factors than are small fires.

In any case, the value of studying shapes is well demonstrated. From a practical perspective, these are all valuable benchmarks for natural pattern emulation strategies. More importantly, the examination of shapes also generates some relevant questions that may lead to an even greater understanding of the relationship between pattern and process.

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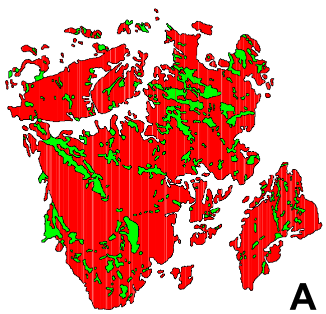
Natural Disturbance Program Quicknote #28

September 2004 *By: David W. Andison*

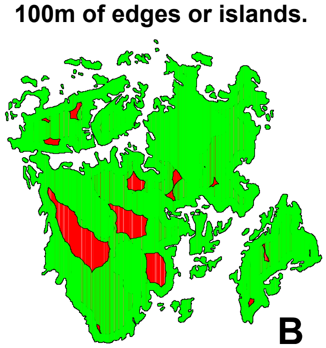
What Do Events, Disturbed Patches, & Islands Have in Common?

They create spatial complexity. The shapes, composition, sizes, and density of these spatial elements combine to make forest fires highly complex entities. As a result, the probability of being in the vicinity of undisturbed forest is fairly high. In fact, in west-central Alberta, an average of 91% of a 100 ha fire is within 100m of either an island remnant or the fire perimeter, and 99% of the area is within 300m. As a reference point, only 32% of the area of a 100 ha circle with no internal islands is within 100m of undisturbed forest. The difference is the combined influence of the convoluted boundaries of multiple disturbed patches (Quicknote 7), and the large number of island and matrix remnants (Quicknote 19, 22).

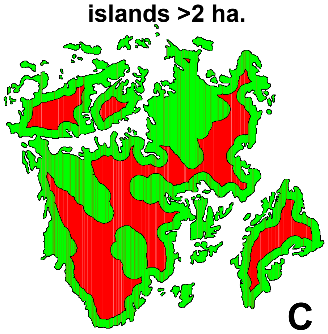
16% of 680 ha fire area in island remnants.



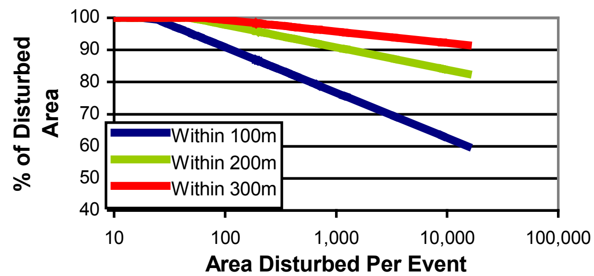
92% of burnt areas within 100m of edges or islands.



67% of burnt areas within 100m of edges or islands >2 ha.



Percent of Disturbed Areas Within a Specified Distance From Undisturbed Forest



Larger fires have less of their area near un-burnt patches, but even 1,000 ha fires average 77% of their area within 100m of islands or edges (compared to just 11% for a 1,000 ha circle with no islands). Even fires 10,000 ha in size have an average of over 84% of their area within 200m of un-burnt forest (see Fig above).

This simple exercise of combining what we already know about the key spatial elements of a disturbance event allow us to begin making critical links between pattern and process. In this case, distance to undisturbed forest is relevant for seed dispersal for tree species with heavy seeds (such as white spruce), survival and dispersal of slow moving species (such as beetles), and, forage, nesting, and predator flight functions for other resident species. These are all fundamental biological functions.

Making the pattern-process link also allows us to evaluate the relative importance of different pattern elements. For example, the contribution of very small islands to spatial complexity is significant. In the 680 ha fire shown on the left, 92% of the area is within 100m of undisturbed forest (box B). However, only 67% of the area is within 100m of undisturbed forest areas larger than two hectares (box C). This clearly demonstrates the (biological) risks of disregarding small islands. It also suggests that area (of residuals) is not necessarily more important than density. Similar arguments could be made for simplifying the shapes of disturbed patches, or clustering the spatial distribution of islands.

Perhaps the most powerful lesson demonstrated here is that no natural pattern is irrelevant.

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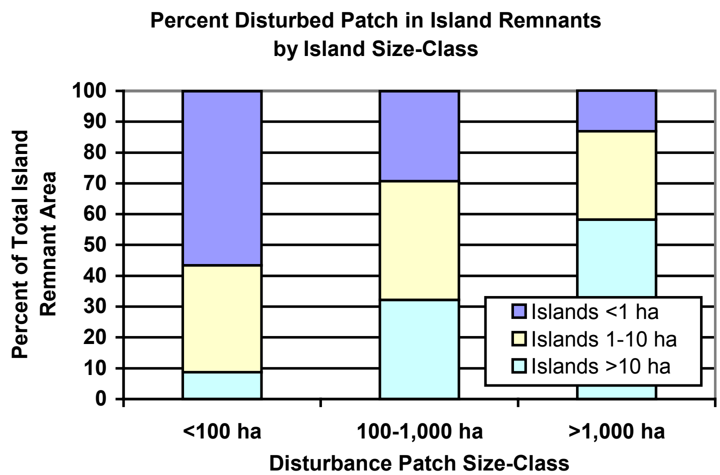
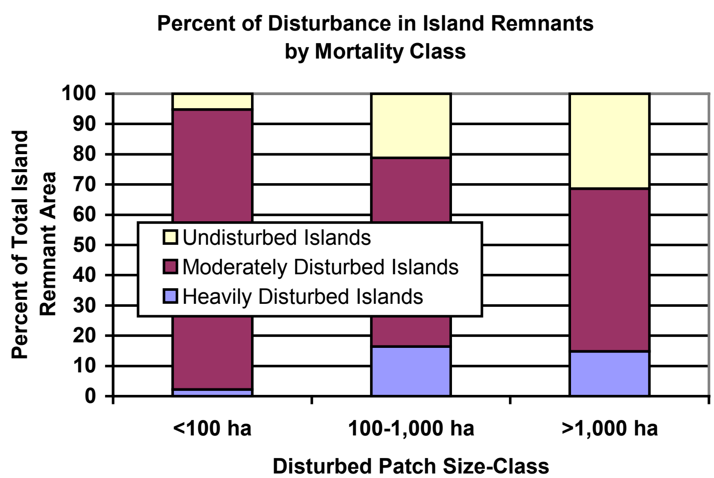
Natural Disturbance Program Quicknote #29

November 2004 *By: David W. Andison*

Island Details: Relevant Patterns or Trivial Pursuits?





It is always possible to dig one layer deeper when studying patterns. For instance, we have already determined that remnant islands account for 10-12% of the area of historical fires in west-central Alberta, regardless of fire size (Quicknote 18). However, these same data reveal that islands within smaller fires differ both in size and structure than islands within larger fires. For example, within disturbed patches less than 100 ha in size, islands smaller than 1 ha account for 56% of the total area in islands, while islands larger than 10 ha contribute only 9%. In contrast, small islands (<1 ha) contribute only 13% of the total area in islands for fire patches larger than 1,000 ha, while large islands (>10 ha) account for 58%.

Island mortality levels are also significantly related to fire size. Islands with intermediate levels of mortality account for 94% of all island area in disturbances 100 ha or smaller, but only 54% of island area for disturbances larger than 1,000 ha. Islands with no mortality account for only 5% of island area in small disturbances (<100 ha) compared to 31% for larger disturbances (>1,000 ha).

Thus, the relative occurrence of small islands and moderately disturbed islands is significantly higher in small disturbances than in larger disturbances. This raises some interesting questions. First, from a process perspective, does this suggest that small fires burn fundamentally differently than larger ones – perhaps as a result of increased variability in fire intensity, speed, or residence time over time and space? Or is this simply a reflection of the influence of available fuel and topographic differences over different sized areas?

The second, more difficult, question is; are these shifts in island sizes and types ecologically relevant? The answer to this question is unknown, but it is not inconceivable that the ecological role of islands varies. For example, one would expect that smaller, less intact islands function mostly as seed sources (see Quicknote 28), and larger islands with little or no mortality are more relevant for forage, and cover from predators.

It is also possible that the differences noted in island types and sizes have no significant or specific biological relevance. Perhaps the most important island pattern, beyond total area and perhaps spacing, is that of variation – having as many different types of islands as possible. In the end, the only way to know for sure is to use these, and other coarse filter results, as hypotheses for fine filter studies designed to focus on the biological significance of different patterns.

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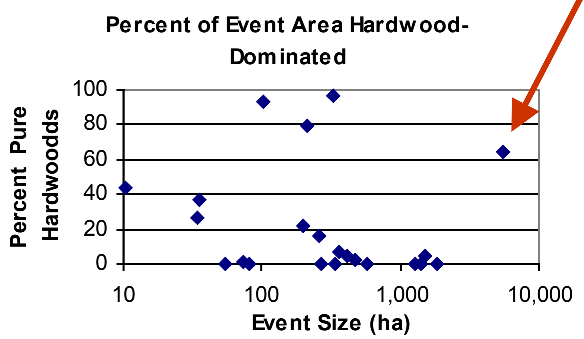
Natural Disturbance Program Quicknote #30

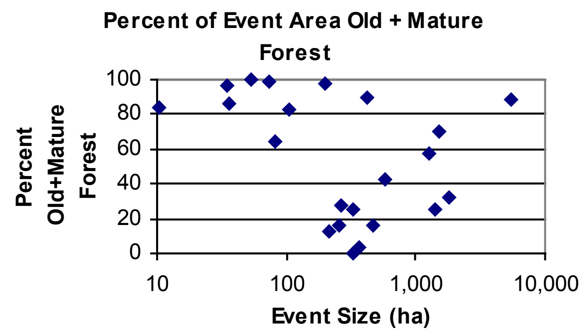
January 2005

By: David W. Andison

Can Fuel-Type be Used to Predict Event Size?

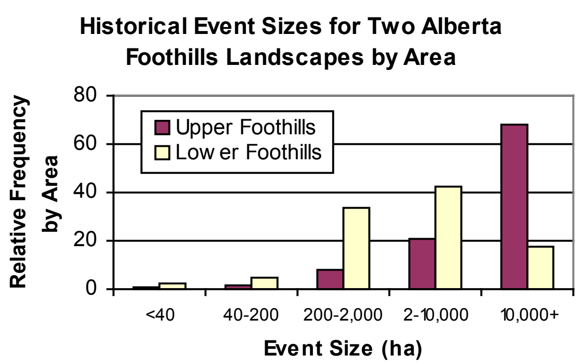
Not alone. In west-central Alberta, fire event size is unrelated to soil moisture, the proportion of non-forested areas, or pre-disturbance species composition, density, age, or height. One might expect to find, for example, that smaller fires tend to occur in areas dominated by younger forest or hardwood leading stands. In fact, neither hypothesis is true (see figures below). For instance, the largest historical fire event in the dataset (5,500 ha) occurred in an area dominated by aspen stands within the Lower Foothills landscape.

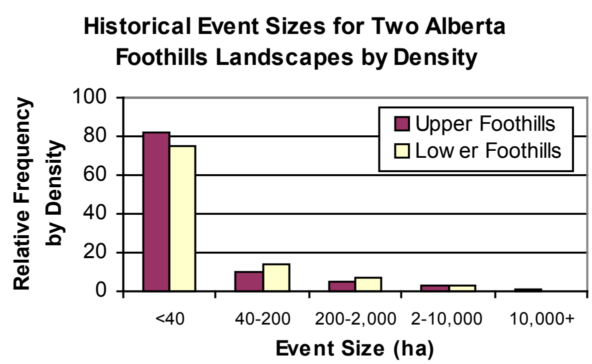




One should not necessarily conclude from this that fuel-type has no influence on fire size. Rather, the findings suggest that fuel-type *alone* is not a reliable predictor of fire size. Recall from Quicknote #2 that fire size varies by landscape, which corresponds to fundamental differences in climate, ignition sources, topography, and vegetation (*i.e.*, fuel type). Thus, logically, *all* of these factors influence fire size.

So, perhaps a better question is*: In what way* does fuel-type influence fire size? By way of an answer, consider that fires larger than 10,000 ha on the mixedwood-dominated Lower Foothills landscape account for about 17% of the historical fire area, compared to 68% by area for the Upper Foothills (see below). While this represents a significant difference in area, it translates into only marginally higher numbers of large fires. In fact, if just a handful of fires were at least 20,000 ha instead of 1,000 ha in the Lower Foothills landscape, the frequency distributions of the two landscapes would be fairly similar.





These small differences are the product of a combination of factors, but it is not difficult to imagine that fuel-type is prominent among them. For example, had the 5,500 ha fire event noted above occurred in the softwood-dominated Upper Foothills landscape under the same burning conditions, it is reasonable to assume that it would have been larger – perhaps much larger. Thus, although fire size cannot be predicted by fuel-type information alone, it is almost certainly a factor contributing to fire size thresholds. More specifically, perhaps fuel-type is more important for defining the *shape* of fire event size distributions (such as those shown above), while fire weather factors help regulate the exact size, or *position*, of each fire event within those distributions.

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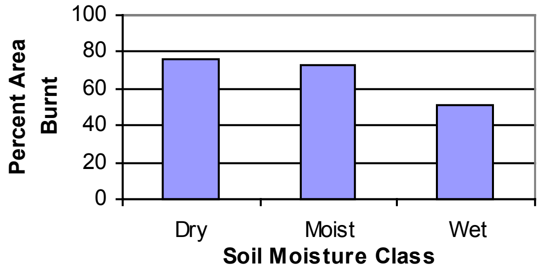
Natural Disturbance Program Quicknote #31

March 2005 *By: David W. Andison*

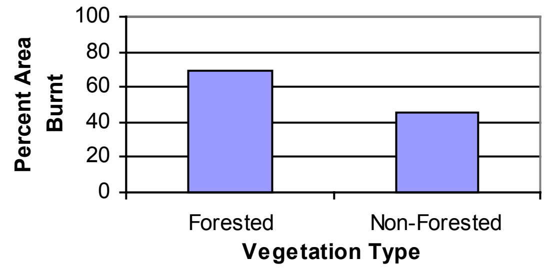
Does Fuel-Type Have *Anything* to Do With Fire Patterns?

Yes. If we compare what burned to what did not burn within a buffered area of historical fires in west-central Alberta, the stand-level attributes that fires most respond to are soil moisture and the presence of trees. For example, on average, about 76% of the area defined as having “dry” soils burned, compared to only 51% of those areas defined as having “wet” soils. Similarly, 70% of forested areas burned within historical fires, compared to only 45% of non-forested areas within the same fires.

Percent of Land Burnt by Soil Moisture

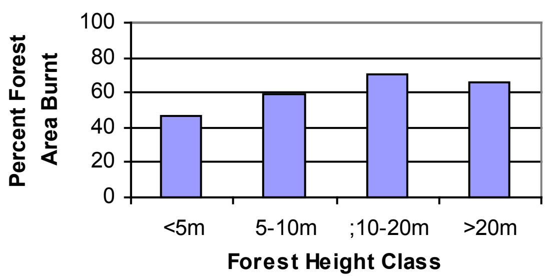


Percent of Land Burnt by Vegetation Type

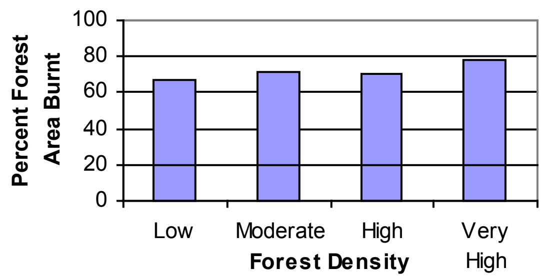


Fire patterns also respond to both the height and density of pre-fire stands, although to a lesser degree than either soil moisture or the presence of trees. For example, 46% of the area of forest less than 5m tall burned, compared to 68% of the forested area with trees taller than 20m. Surprisingly, the proportions of areas that burned in different age-classes and tree cover-classes were not significantly different.

Percent of Forest Burnt by Height Class



Percent of Forest Burnt by Density Class



The conclusion that wet sites are less likely to burn seems to conflict with the observation that aspen stands are just as likely to burn as conifer-dominated stands. One possible explanation for this discrepancy is that the *relative* fuel-moisture level of hardwood stands is not a constant throughout the burning season. Another possible explanation is that wet sites are highly related to areas that have no trees, representing a fundamentally different spatial arrangement of fuels.

It is also interesting to note that fire patterns, on average, respond more to the size and density of trees than to species or age. Once again, one could argue either that 1) hardwoods function as different fuel-types depending on the time of year, or 2) the spatial arrangement of fuel (vertically and horizontally) is more important, on average, than the *types* of fuels.

In the end, the influence of fuel-type on the burn patterns of individual fires varies widely, likely in response to both the time of year and fire weather conditions. It is important to realize that in these data represent the *averaged* effects over the full range of burning conditions and timing.

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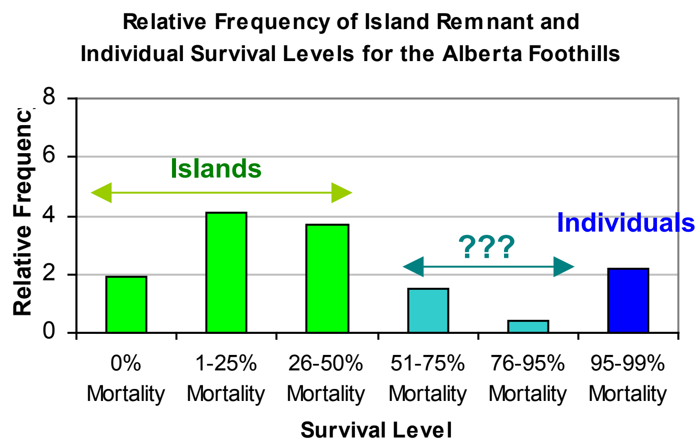
Natural Disturbance Program Quicknote #32

May 2005 By: David Andison and Kris McCleary

Surviving as an Individual?

Barely. The vast majority of the area of the Virginia Hills fire of 1998 has no surviving trees *that are not associated with island or matrix remnants*. In fact, only about 2% of the disturbed area of the Virginia Hills fire contains individual survivors. As a point of reference, recall from Quicknote #18 that island remnants account for an average of 12% of the disturbed area of historic fires in west-central Alberta.

But how does one differentiate *individuals* from either low-density, or very small *islands*? There are no definitive rules. Recall from Quicknote #19 that the lowest survival class of islands in the FMF database is only 6-25%, which means that *individuals* are found below the 6% survival threshold. This threshold was based largely on aerial photo interpretation capabilities, so it is simple enough to modify if one has all of the relevant data. For instance, one may choose to use 50% mortality as the line between *islands* and *individuals*, in which case the contribution of islands would decrease to about 10% by area, and individuals would account for 4% by area. The adjacent figure shows the relevant areal contributions of the different survival classes of islands (from Quicknote #19) together with the data on individuals from the Virginia Hills fire.



The same argument could be made for the inclusion of tiny clusters of surviving trees as *islands* as opposed to *individuals*. The FMF data used a lower size limit of about 0.01 ha, or 10 meters square for islands. If one chose a new threshold of, say 25 meters square to represent islands, this would account for about 8% of the total number of islands in our dataset, but only a fraction of a percentage of the total area in islands.

In the end, we have to be careful not to let arbitrary classifications obscure the relevance of the natural patterns revealed. Regardless of how we might define different types of residuals, the fact is that the majority of the area of forest fires in west-central Alberta experience 100% mortality. There is no evidence to suggest that residuals here survive uniformly, or even randomly, spatially across a burn. Simply put, residuals - *of all types* - tend to cluster in space.

This is a significant finding. It means that although residual classifications can be chosen arbitrarily, they must be defined very specifically, and applied consistently. It also means that residuals are best represented by areal calculations. For example, the statement “the fire had 10% survival” may be accurate, but misleading. A more precise statement would be “residual areas (which would include all levels of survival) account for 10% of the fire area”.

foothills MODEL FOREST research growing into practice.

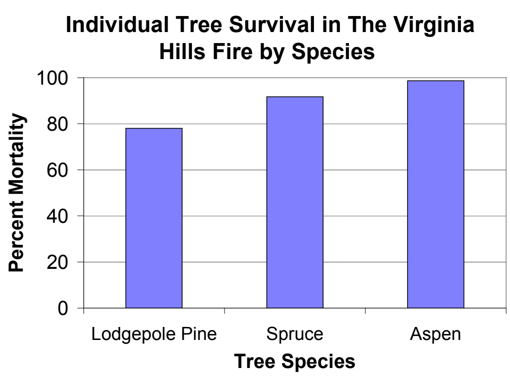
Natural Disturbance Program Quicknote #33

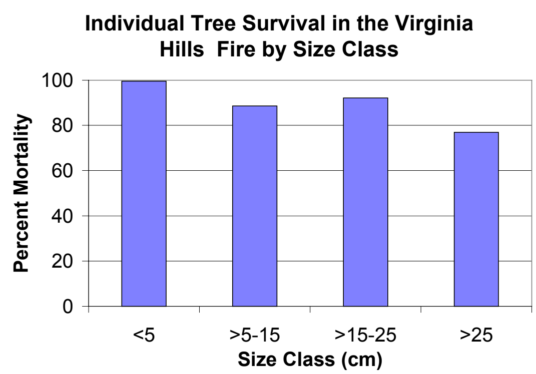
July 2005 *By: David Andison and Kris McCleary*

What Tends to Survive as Individuals?

In the Virginia Hills fire, softwoods and large trees had the best chance of surviving. Of those individual trees *not* in island or matrix remnants, the Virginia Hills fire of 2000 in Alberta killed a higher proportion of aspen stems relative to spruce and pine, and a higher proportion of small stems relative to large ones. (Note: An "individual" is defined here as a living stem located within areas of less than 6% survival).

For example, almost 99% of individual aspen stems – those not within island or matrix remnants (see Quicknotes 18, 22) - were killed by the Virginia Hills fire. In contrast, 92% of individual spruce stems were killed, and only 79% of individual lodgepole pine stems were killed. Similarly, virtually all stems smaller than 5cm DBH were killed by the fire compared to only about 78% of stems larger than 25cm DBH.





The survival patterns noted here raise some interesting questions since they seem to conflict with other residual pattern findings. For example, Quicknotes 24,30, and 31 suggest that tree species has only a marginal influence on the size, boundaries, or residual levels of fires.

The difference could simply be a function of the unique nature of the Virginia Hills fire. The patterns of a single fire cannot possibly represent the full range of natural conditions. However, the apparent inconsistency does compel us to at least consider the possibility that individual survival patterns may differ from island remnant survival patterns. For example, perhaps areas of higher burn intensity (in non-island areas) are more selective. This is not an unreasonable hypothesis. Islands, as defined here, have survival levels that range between 6-100%, and thus represent lower fire intensity conditions relative to non-island areas. All other things being equal, the chances of survival for species or stems easily killed by fire (such as aspen) are greater where fire intensity is lower.

Another possibility is that the apparent inconsistency is the result of a shift in the scale of observation. Residual survival results relate to the entire fire area, and not a stem-by-stem inventory of survival within individual remnants. So, it is still possible that the *location of residuals* may not be related to tree size or species patterns, but the *survival of the individuals* within those residuals is. In other words, fire is perhaps more selective at fine scales than at coarser scales.

In the end, while it is not possible to extrapolate these findings towards a more general statement of individual tree survival, it does generate some new, valuable, and very specific hypotheses about the survival mechanisms of all residual elements. The results also help foster a better appreciation of how complex fire patterns, and their associated processes, can be.

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Natural Disturbance Program Quicknote #34

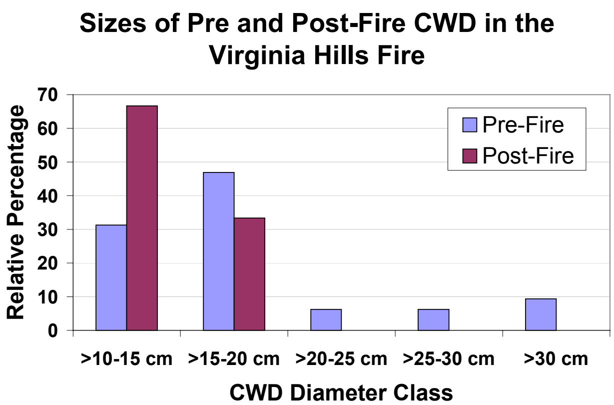
October 2005

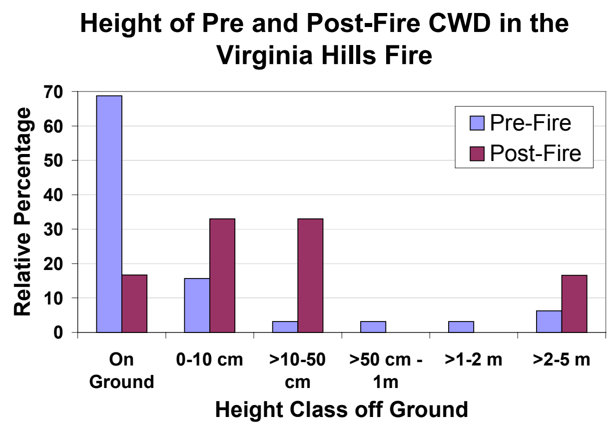
By: David Andison and Kris McCleary

How Do Wildfires Generate Coarse Woody Debris?

Over time. In the Dogrib Fire of 2001, only 8% of the (downed) coarse woody debris (CWD) was created within two years of the fire, and 16% of the existing CWD was created within three years of the Virginia Hills fire of 2001. Given that wildfires in west-central Alberta historically kill an average of 62% of the trees within a given disturbance event (ND Quicknotes #18 & 22), these CWD percentages represent only a fraction of the trees killed by the fires. In other words, for these fires*, there was no obvious large post-fire "pulse" of CWD recruitment.*

Furthermore, the CWD generated after the Virginia Hills fire is likely to be small and suspended off the ground. Pre-fire CWD ranged from 10-35 cm in diameter, but the CWD generated by the Virginia Hills fire was all less than 20 cm in diameter. Also, almost 70% of the CWD existing before the Virginia Hills fires was touching the ground, compared to only 17% of the CWD created from the fire itself.





One interpretation of these findings is that the consumption of the root systems by fire, combined with the physical power of the fire, was insufficient to de-stabilize anything other than the smallest trees killed by the fires. And, after 2-3 years, each fire area has already experienced a range of seasonal (wind, ice and snow) storm conditions. Thus, it is reasonable to presume that the only reason for a pulse of new CWD at this point is a storm event of unusual severity.

It is important to keep in mind that the data for these results come from only two wildfires. The single most important message from the FMF ND research is that natural levels of variation in wildfire patterns are universal. However, even if these two fires represent one extreme, they still provide considerable insight. For example, there is an obvious difference between (standing) dead trees, and (downed) woody debris. Clearly, not all wildfires create large pulses of CWD. And even for those that may do so, the prominence of elevated CWD identified here is telling. Since decay rates of dead wood are directly related to contact with the ground, most of the large dead wood generated from these two wildfires will require extended periods to fully decompose.

Perhaps the focus on CWD alone is ill advised. Based on these findings, it is possible to identify at least three different physical forms of dead wood created from fires; 1) standing dead, as specialized habitat (*e.g.*, cavity nesting birds), 2) downed aerial, as specialized habitat (*e.g.* small mammals), and 3) true downed woody debris as both specialized habitat and a soil nutrient source. Clearly, wildfires produce all three types of dead wood, although likely in different proportions, and over different periods of time.

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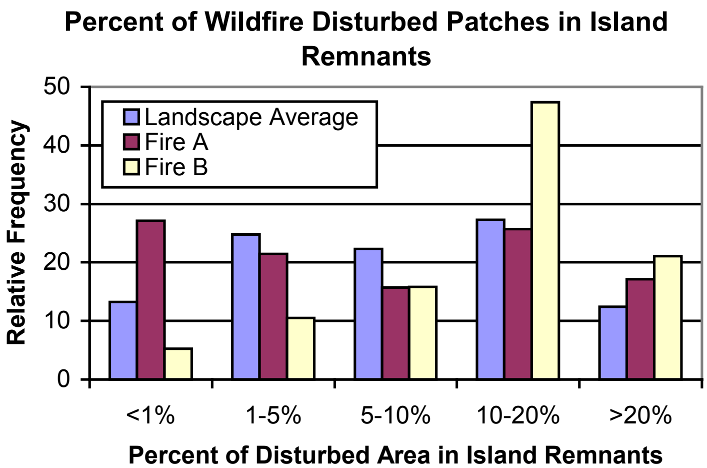
Natural Disturbance Program Quicknote #35

January 2006

By: David Andison

Which is More Important: Variability Between Fires or Within Fires?

Both. The blue columns in the Figure below depict the average frequency distribution of island remnant area for all disturbed patches within 25 wildfires across west-central Alberta – in other words, a landscape average of island remnant levels. Recall that a disturbance event can have many disturbed patches (Quicknotes #4, #7, #13).



If each wildfire represents unique burning conditions, then one might expect the island remnant levels within fires to be similar. Thus, the distribution of the blue bars in the adjacent Figure would be largely due to differences *between* fires.

In reality, there is almost as much variation *within* fires. For example, the largest fire in our sample shows variability in island remnant levels similar to the landscape average (Fire A in the adjacent Figure). Island remnant levels within disturbed patches of the second largest fire (in yellow) cluster moderately between 10-20%, but the full landscape range is still well represented. In fact, island and matrix remnant levels from all fires in the database show little tendency to cluster based on either event membership, or event size.

Consider what this means. We have established that residual patterns within fires are highly variable. We already know that fuel-type is only marginally related to the probability of burning within a wildfire (Quicknotes #24, #31), which suggests that some combination of fuel and fire weather conditions is responsible for most of the observed variability in residual levels. But it is also well documented that extreme fire weather and fuel conditions are associated with larger fires. So why is there not a relationship between fire size and/or burning conditions and residual patterns? *Why do we not find clustered residual levels for individual fires in west-central Alberta?*

There are several possible explanations. Fire weather may function on different spatial scales. So although there may be a narrow set of (temperature, relative humidity, wind, etc) parameters for a given fire at a given point in time, there is likely a much wider range of site–specific fire weather conditions. Fire weather is also variable over time. Many of the fires in our database burnt over several weeks, during which time weather conditions no doubt varied widely. Consider also that almost half of time, wildfires burn at night. In fact, the proportion of time during which forest fires grow significantly in size may be very short relatively to the duration of each fire. Another possibility is that burn preferences may shift between small and large fires, or during less and more severe fire weather conditions within a single fire. So although *what* burns may significantly change over the course of a fire, *how much* burns may not.

In all likelihood, all of these explanations apply, plus a few others. But in the end it is more important to appreciate that the variability of residual survival patterns within individual fires can be almost as great as that for entire landscapes.

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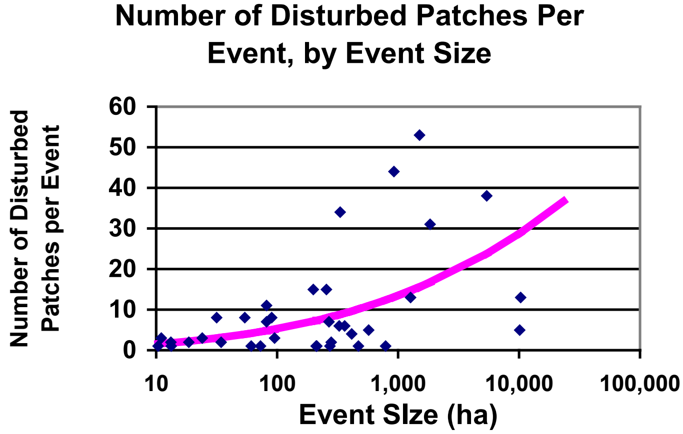
Natural Disturbance Program Quicknote #36

April 2006 *By: David W. Andison*

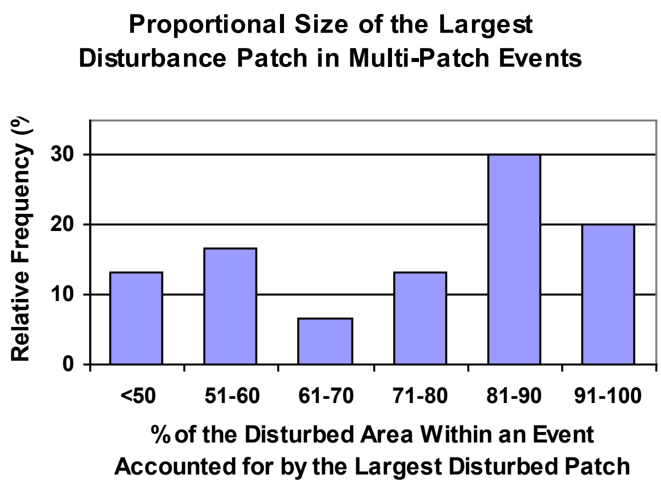
The Untidy Wildfire

Wildfires in west-central Alberta tend to be patchy – very patchy. Even wildfires less than 15 ha in size can have two or more individual burnt patches. However, there is nothing haphazard about these wildfires in terms of the *density, sizes*, or *spacing* of burnt patches.

1) Density. As wildfires get bigger, the number of disturbed patches increases. For example, the average 100 ha wildfire event includes five separate disturbed patches, and a 1,000 ha event has, on average, 13 disturbed patches.



2) Sizes. Wildfires in this landscape almost always consist of one large burnt patch surrounded by several smaller ones (see Quicknote #13). In fact, the largest patch is always at least 50% of the total burnt area, and half of the time, the largest burnt patch accounts for at least 80% of the total area burnt. Furthermore, the proportional size of the largest burnt patch is unrelated to fire size.



3) Spacing. The average distance between burnt patches increases as wildfires become larger. For example, all of the burnt patches within wildfires smaller than 1,000 ha are within 200m of each other, but in fires larger than 5,000 ha, some of the burnt patches are more than 500m apart.

To summarize, west-central wildfires tend to have one large burnt patch surrounded by a number of smaller burnt patches. As fires become larger, the relative size of the single large burnt patch stays constant, but the number of smaller burnt patches increases, as does the distance between them.

The patterns noted here suggest that forest fires in the foothills of Alberta commonly generate "spot-fires" - frequently attributable to wind-born embers. The evidence also suggests that spot fire activity increases with larger fires.

The ecological significance of multiple burnt patches is unknown. However, we do know that multiple disturbed patches create high levels of intermediate-scale structural complexity, which is not difficult to appreciate as biologically relevant. We also know that undisturbed areas between disturbed patches (or, "matrix remnants") are the dominant type of residual within natural wildfires on these landscapes (Quicknote #22).

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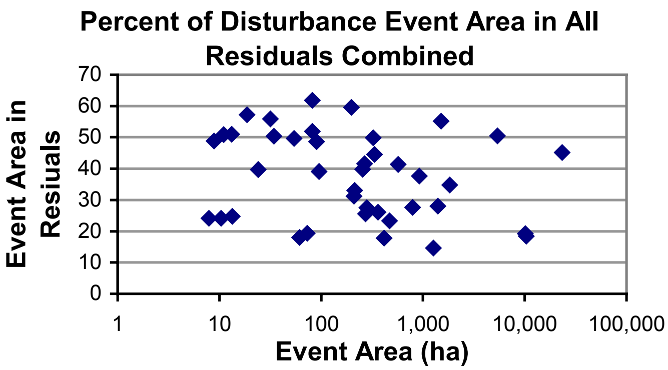
Natural Disturbance Program Quicknote #37

July 2006 *By: David W. Andison*

Wildfire Residuals Are A Package Deal

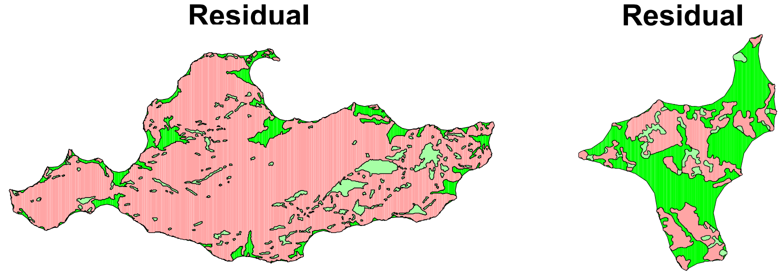
While it is informative to differentiate *island remnants* (Quicknote #18) from *matrix remnants* (Quicknote #22), the fact is that the physical difference between these two major forms of residuals is often small. The presence (or absence) of a single, narrow, partially disturbed strip of vegetation is enough to trigger a shift from one residual category to the other.



It is far more informative to combine the two major forms of residuals into a single overall measure. Total residuals account for an average of 39% of the area of historic wildfire *events* (see Quicknote #7) in west-central Alberta. As with both island remnant and matrix remnant patterns, no relationship is evident between total residual level and fire size, ecological sub-region, local fire weather danger, or the duration of the burn.

Perhaps even more revealing is fact that the variation in total residual level is almost perfectly flat. In other words, there is no central tendency, and there are no rare extreme events. There is virtually an equally probability of any total level of residual occurring between 15-62% in a wildfire of any size (see adjacent Figure for these two extremes).

Wildfire With 15% Residual **Wildfire With 62% Residual**



These are provocative findings. From a fire behavior perspective, it suggests that, within a given range, the <u>*exact level*</u> of unburnt residuals within a wildfire is completely unpredictable based on the location or size of a wildfire. Yet, the <u>*range*</u> of total residual level is remarkably predictable - the upper and lower bounds of historical, natural wildfire residual levels are clearly defined between 15-62%. The findings also strongly suggest that, despite the apparent high severity of foothills wildfires, internal mortality is far from complete. On average, well over 1/3, and no less than 15% of the vegetation survives within wildfire events on these landscapes.

From a practical perspective, the findings further emphasize the importance of finding a robust way of representing the full natural range of residual levels. The average total residual level (39% in this case) may be statistically accurate, but the average is clearly unsatisfactory as a measure of capturing natural levels of total residuals. Furthermore, the fact that the trends are similar to those found for both island remnant and matrix remnant levels suggests that the distinction between the two forms of residuals is blurred. In other words, total disturbance residual levels in disturbance events should be considered as a package first, and only then split into *island remnants* versus *matrix remnants*.

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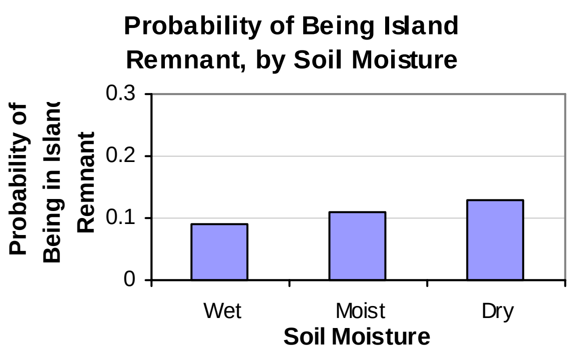
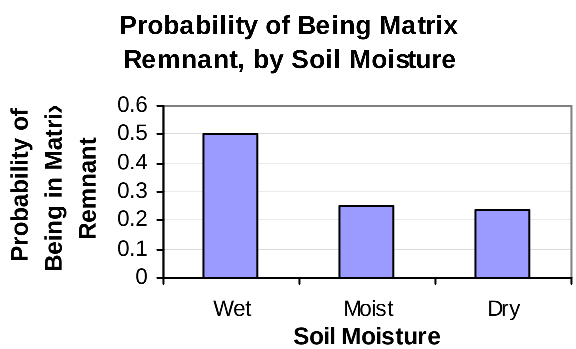
Natural Disturbance Program Quicknote #38

October 2006 ***By: David W. Andison***

When Wildfire Residuals Are *Not* A Package Deal

Recall from Quicknote #31 that the probability of an area being burnt within historical wildfires is related to soil moisture. As it turns out, this does not necessarily mean that all residuals are more likely to occur in wet areas. As the figures below illustrate, wet areas within a given disturbance event are twice as likely to become *matrix remnants* " (see Quicknote #22, Interp. Note #1) than are moist or dry areas. However, wet areas are no more likely to become *island remnants* (Quicknote #18, Interp. Note #1) than are moist or dry areas.





This same pattern is noted for other site, and stand composition, structure, and age variables. In fact, *the location of island remnants is entirely unrelated to any biotic or abiotic factors tested*. In contrast, the location of matrix remnants was moderately related to a number of site and stand factors.

There are several possible explanations for this seeming inconsistency. Islands may be the result of a different fire behaviour mechanism. Perhaps islands are entirely a function of highly localized fire weather conditions in both time and space. The fact that most island remnants are very small (Quicknote #19) supports this theory since it is consistent with a very small window of opportunity. Alternatively, island formation may be a reflection of the spatial arrangement of different fuel-types across the landscape. For instance, one would expect at least part of a small wet black spruce lowland area to burn if it is surrounded by a large dense conifer stand, perhaps even resulting in some “feathering”. The fact that the vast majority of island remnants are partially disturbed (Quicknote #19) supports this theory since it suggests low to intermediate levels of fire severity.

Whatever the reason, we now have three new pieces of information.

1) While the tendency of one part or another of the landscape to burn can be captured (Quicknote #31), the probability of residuals forming on one or another part of the landscape cannot be generalized.

2) The two main types of residuals (islands and matrix) potentially arise from a different set of processes.

3) The spatial definitions introduced by the FMF research have relevance to fire pattern, and potentially to fire behaviour.

So while it is valuable to consider residuals as a package deal with respect to total area (as suggested by Quicknote #37), clearly there is legitimate natural pattern information in the details of those residuals.

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Natural Disturbance Program Quicknote #39

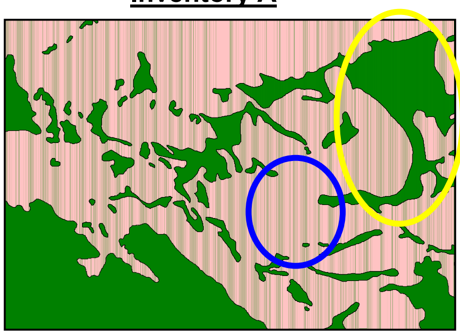
January 2007 *By: David W. Andison*

How Well do Forest Inventories Identify Wildfire Patterns?

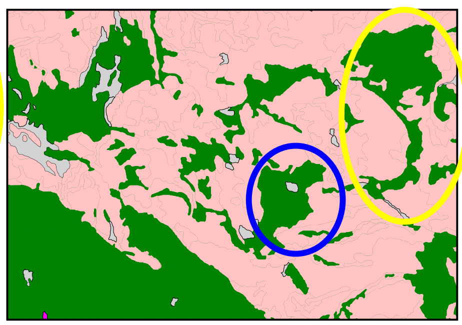
This is an unfair, but timely, question. Forest inventories are designed to identify polgyons based on a large number of structural, compositional, and site factors using recent aerial photos. Identifying historic disturbance patterns is not a priority for forest inventories. Nevertheless, a comparison is informative.

Let's start with an ideal scenario. The images below show burnt (in red) and unburnt (in green) portions of two 3 X 5km sections of a 1956 wildfire that burnt through a mature, pine-dominated forest according to the most recent forest inventory (on the left), and a wildfire pattern map generated from historic photos (on the right). Note that "burnt" for the inventory corresponds to an origin date of 1956, plus or minus five years.

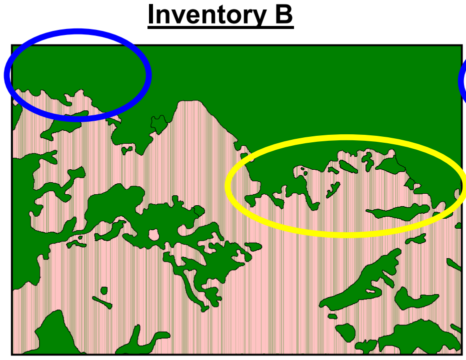
Inventory A



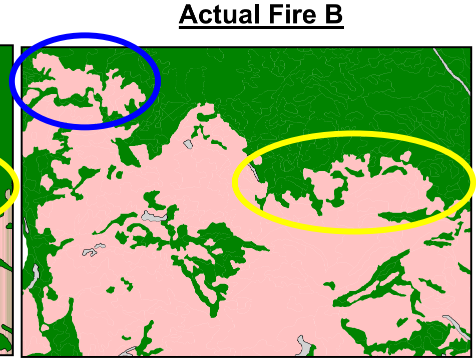
Actual Fire A



Inventory B



Actual Fire B



Fifty years after the wildfire event, the inventory in this case was able to roughly identify the location of many of the more significant residual patterns (yellow circle in example A). The inventory did an even better job of identifying the perimeter of the original wildfire (yellow circle in example B).

Many of the differences found are not unexpected. The blue circle in Example A shows a ~80 ha partially disturbed island remnant that the inventory identifies as burnt in 1956 (with no over-story). One can imagine that a partially disturbed residual would be difficult to identify 50 years later - although several other partially disturbed islands were identified by the inventory. It is also not entirely unreasonable to expect that the inventory would mistake a patch of forest from 1930 (in blue in Example B) as one originating from the 1956 burn. The greatest age differences were associated with black spruce, hardwoods, and low density stands.

Keep in mind that the wildfire example given here is deliberately a perfect world scenario. The conditions for identifying age differences could not be better in terms of age and stand composition. Now, imagine extrapolating these issues to *average* conditions across a boreal landscape. It is hard not to conclude that the ability of inventory data to identify natural disturbance patterns is severely limited. Recall from Quicknote #5 that the forest inventory agreed with a stand origin map only 32% of the time, plus or minus five years. *In the end, there was no significant bias, and no consistent relationship between the aging differences and associated site or stand characteristics. Nor was it possible to significantly improve the ability of forest inventories to represent wildfire patterns through supplemental field sampling and spatial modelling.*

What does this mean in terms of identifying historic wildfire patterns? Don't push (inventory) data beyond its originally intended use. It is an unfair expectation, impossible to defend, and cannot be corrected or improved through sampling and modelling. Wildfire patterns can only be gleaned from spatial data specifically collected to study wildfire patterns.

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Natural Disturbance Program Quicknote #40

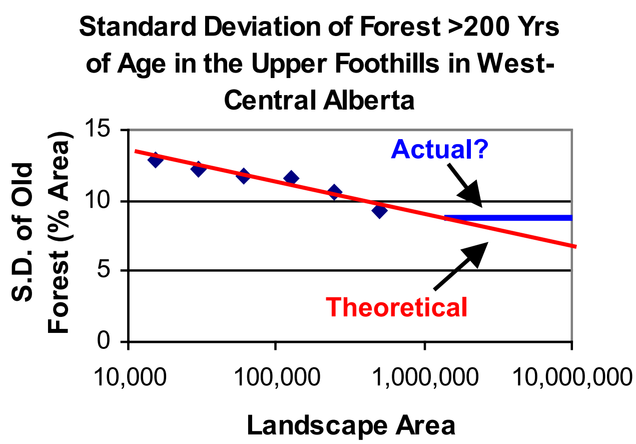
April 2007

By: David W. Andison

Do Large Landscapes Have Stable Old Forest Levels Over Time?

In the Alberta foothills at least, the answer is *probably not.*

One hundred landscape snapshots from a spatial modelling exercise were captured at six different spatial scales for the Upper Foothills natural subregion in west-central Alberta. The standard deviations (SD) of the percent area in old forest for each set of runs were calculated (shown as blue dots in the figure below). When the relationship is extrapolated to larger landscapes (red line in the figure below), the theoretical "stable" landscape size for old forest over time (at which point the standard deviation is zero) exceeds the total area of the boreal forest in Canada.



The extrapolation of a relationship so far beyond raw data is admittedly highly dubious. The red line shown here is unlikely to be the actual relationship. Still, the exercise demonstrates two important points;

1) The variation of old forest levels changes (decreases in this case) as landscape size increases (see Quicknote #17 for more details), and
2) *Under constant conditions*, there is no evidence that old forest levels become stable at some threshold landscape size.

However, in reality, we know that the assumption of *constant conditions* is unrealistic. Finding a landscape even 2-3 million ha in size (let alone 10 million ha) with stable climate, vegetation, and topographic conditions is unlikely in the Canadian boreal forest. We know that even minor changes in climatic, vegetation, and topographic conditions are associated with changes in the natural disturbance regime, which will ultimately influence old forest levels (see Quicknotes #1 and #2). We also know that climatic variation plays a significant role in wildfire activity across huge areas of the boreal. So as landscape size increases, the number of fire regimes multiplies, climate remains variable, and the chances of old forest levels becoming *more* stable (or less variable) declines. In fact, at some point, the variability of old forest levels may level off at some threshold landscape size (see the blue line above for one possibility), or even begin to increase again. *In other words, it is possible that the red line in the figure above represents a theoretical minimum value of old forest level variability.*

Details aside, there are considerable practical implications associated with the trends noted here. First and foremost, this exercise suggests that the cycling of old forest areas from low to high levels occurred historically at regional, and even biome scales. Presumably, this cycling functions as a form of landscape resilience, ultimately linked to long-term forest health. For example, the severity of the current mountain pine beetle (MPB) outbreak is arguably in part a result of our successful efforts to "stabilize" the area of older forest at moderate to high levels through forest management and fire control efforts. And the situation was not caused by traditional forest management and fire control efforts *per se*, but rather by adopting similar criteria and applying the same strategies and rules everywhere at the same time.

This suggests that the active management of old forest levels should include regional and provincial scales. At the very least, this creates an appropriate vehicle for managing trans-boundary threats (i.e., MPB) and issues (i.e., habitat) as the need arises. For example, adequately sized habitat for some old forest dependent species are far more likely to be achieved through provincial old forest strategies than relying on the cumulative impacts of landscape specific targets. It also creates a biological framework for considering variable levels of old forest over time at regional or provincial scales, perhaps in response to critical economic, social, or ecological concerns.

For more information on this or other ND Quicknotes, please contact: Dr. David Andison, Bandaloop Landscape Ecosystem Services, Tel.: (604) 939 – 0830, Email: andison@bandaloop.ca, or visit www.fmf.ab.ca

Natural Disturbance Program Quicknote #41

July 2007

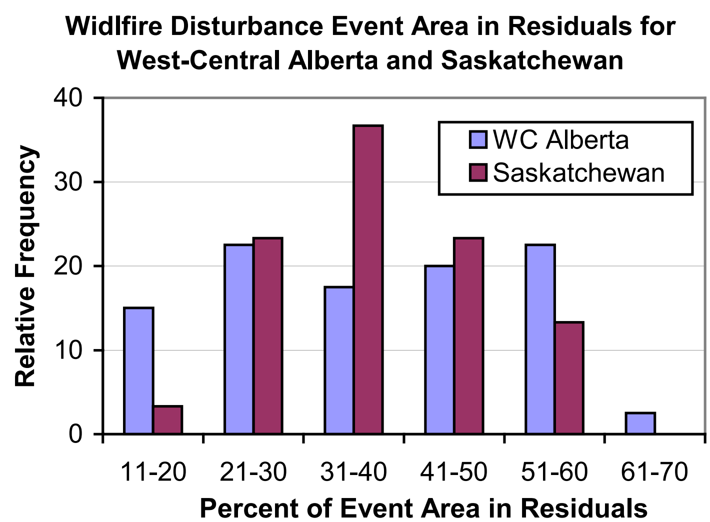
By: David W. Andison

Wildfire Residual Levels: Foothills vs. Saskatchewan

It has been hypothesized that residual levels within wildfires are significantly related to 1) wildfire size and, 2) the landscape in question. We already have evidence to suggest that the first assumption does not hold for foothills landscapes (see Quicknote #18). As to the second question, although our wildfire database includes fires from three different natural sub-regions within Alberta, no statistically significant difference in overall residual levels was found. One possible reason for this finding is that the variability within landscapes was just too high relative to variation between landscapes from our sample. In other words, perhaps the landscapes are not just different enough. Fortunately, we are able to extend the scope of this question by comparing survival patterns from foothills wildfires with matching wildfire data collected from Saskatchewan.

For context, Alberta foothills landscapes differ significantly from those in Saskatchewan in terms of topography, climate, vegetation, soils, and historical fire frequency. At their closest point, they are hundreds of kilometres apart. The only significant things they have in common are that both are within the boreal forest biome, and both are heavily influenced by wildfires.

Applying the same spatial language to each dataset, the total residual levels of Saskatchewan wildfire events (see Quicknotea #7, 10 and 16) are no different than those of wildfire events in west-central Alberta. The average total area in residuals for Alberta foothills wildfires is 37.7%, compared to 35.8% for Saskatchewan. And even without the benefit of statistical testing, it is obvious that the frequency distributions of the two residual levels are similar (see adjacent Figure).



So why would overall residual levels of wildfires be similar between two entirely different parts of boreal Canada? At first blush, it would seem to suggest that topography, vegetation, soils, and even wildfire frequency have no influence on residual levels. In other words, once a fire starts, the residual levels of that fire are almost entirely a function of local burning conditions (*i.e.,* fire weather). If this is true, it suggests that there may actually be some universal patterns of wildfires.

However, another possibility is that the various factors influencing mortality levels within a wildfire have cancelled each other out. For example, a greater prevalence of summer drought in Saskatchewan may result in a higher average fire danger level than in the foothills, which translates into more intense (*i.e.*, hotter) fires. However, those fires may be no more severe (*i.e.*, may result in the same amount of mortality) because Saskatchewan has a far greater proportion of less flammable hardwood and mixedwood forests relative to the conifer dominated Alberta foothills.

In the end, although the mechanism may be unclear, the similarities in residual patterns between the two areas are undeniable. It begs the question of whether this pattern holds across other parts of boreal Canada, or for that matter any other forested landscapes influenced by wildfires. It also raises the question of whether wildfires in these two areas share other pattern characteristics.

Many thanks to Mistik Management, the Saskatchewan Forest Centre, and Saskatchewan Environment for the use of their data for this Quicknote.

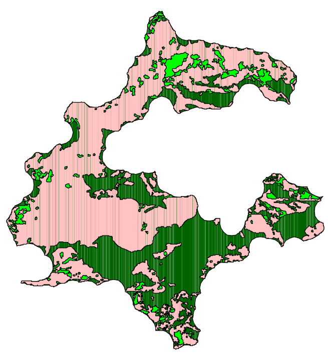
For more information on this or other ND Quicknotes, please contact: Dr. David Andison, Bandaloop Landscape Ecosystem Services, Tel.: (604) 225 – 5669, Email: andison@bandaloop.ca, or visit www.fmf.ab.ca

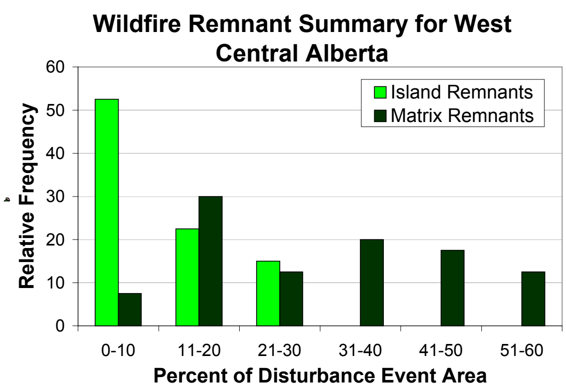
Natural Disturbance Program Quicknote #42

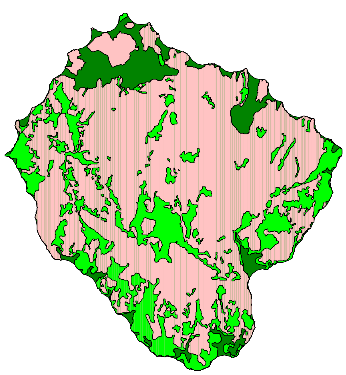
October 2007 ***By: David W. Andison***

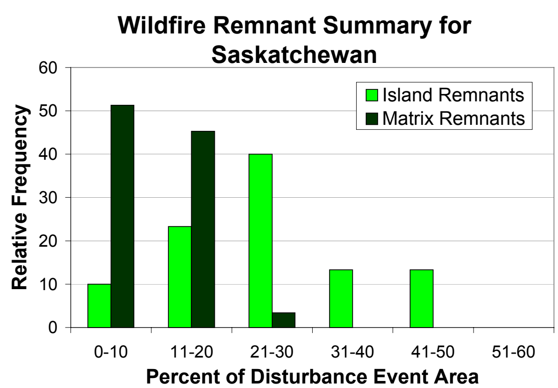
Are Wildfire Patterns in West-Central Alberta and Saskatchewan Identical?

No. Although total residual levels are similarly distributed (see Quicknote #41), the type of residual varies. West-central Alberta wildfires are dominated by matrix remnants (Quicknote #22), while Saskatchewan wildfires are dominated by island remnants (Quicknote #18). On average, island remnants (light green the figure below) in WC Alberta wildfires account for 12% of the disturbance event area, compared to 26% for matrix remnants (in dark green). For wildfires in Saskatchewan the relative contribution is reversed; 24% as island remnants, and just 12% as matrix remnants.









This distinction is not just semantic. Recall that matrix remnants by definition always survive perfectly intact while island remnants (in both locations) are mostly partially disturbed. So another way of differentiating the patterns in this case is that Saskatchewan wildfires have significantly more partially disturbed residuals.

The most obvious explanation for the pattern differences noted here is that the fires are being influenced by fuel-type. Saskatchewan forests have significantly higher levels of hardwood and mixedwood stands compared to landscapes in west-central Alberta. Hardwoods are not only less flammable, but also less adapted to survival from fire than conifers. So mixedwood landscapes are in theory more likely to result in significant areas of partial mortality.

However there exist other possible explanations for this phenomenon. For example, the more complex topography of the Alberta foothills may be creating conditions that facilitate more discrete burn patterns, perhaps through secondary effects on wind. Another possibility is that the local weather burning conditions are more variable (from day to day, or even hour to hour) over the life of wildfires in Saskatchewan relative to wildfires in west-central Alberta

Many thanks to Mistik Management Ltd., the Saskatchewan Forest Centre, and Saskatchewan Environment for the use of their data for this Quicknote.

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Natural Disturbance Program Quicknote #43

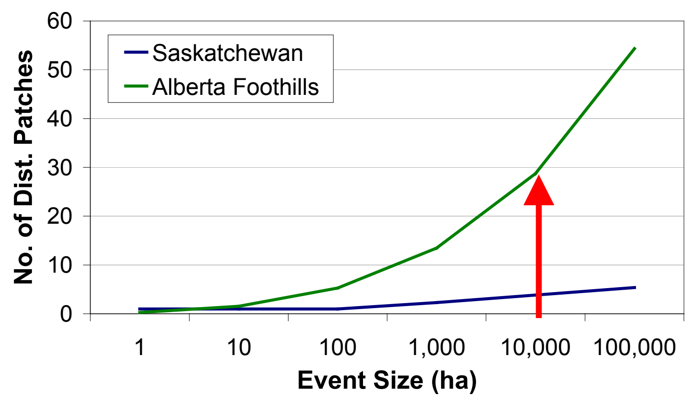
January 2008 *By: David W. Andison*

Disturbance Event Patterns: Alberta Foothills vs. Saskatchewan

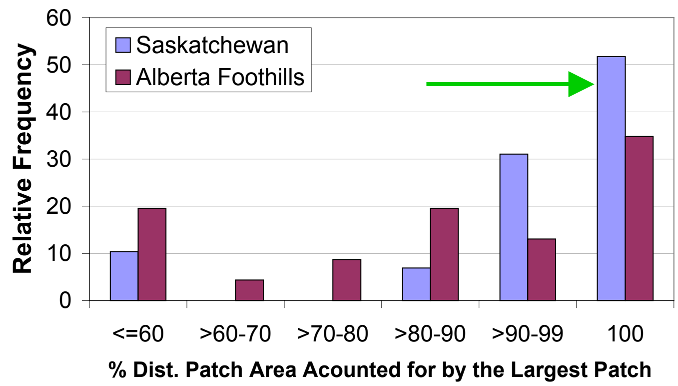
From the outline of a natural wildfire event, it would be impossible to tell the difference between one from Saskatchewan from one from the Alberta Foothills – their shapes are similar. However, the internal structure of wildfire events from these two landscape is quite different.

Alberta Foothills wildfires tend to be a cluster of many differently sized disturbed patches, while Saskatchewan wildfires are usually dominated by a single, very large, disturbed patch. For example, a 10,000 ha wildfire in Alberta averages 29 disturbed patches compared to only four for a Saskatchewan wildfire of the same size (see the red arrow in the Figure adjacent). Furthermore, the largest disturbed patch in a 10,000 ha Alberta wildfire will account for an average of 73% of the disturbed area, compared to 88% for Saskatchewan. In fact, there is less than a 50% chance that the Saskatchewan wildfire has more than one disturbed patch (see the green arrow in the adjacent Figure).

Number of Disturbed Patches per Event for Saskatcheawn and Alberta Foothills Wildfires



Percent of Disturbed Patch Area Acounted for by the Largest Patch for Wildfire Events in Saskatchewan vs. Alberta Foothills



The contrast noted here is consistent with what we already know about other pattern metrics. Recall from Quicknote #42 that Saskatchewan wildfires tend to have far less area in *matrix remnants* than do Alberta Foothills wildfires. Recall also that matrix remnants include areas in corridors between disturbed patches. So there is a direct, logical relationship between the area in matrix remnants and the number of disturbed patches.

The obvious question this evidence raises is whether fire behaviour differs between the two areas. Are wildfires in the Foothills more likely to skip or "spot" relative to wildfires in Saskatchewan? Or are we mistaking a spatio-temporal phenomenon for a simple spatial one? For example, what if Saskatchewan wildfires spot just as often as do Alberta Foothills fires, but at different times during the burn? Similarly, perhaps high contrast "fire ending" weather events are less common in Saskatchewan (compared to more gradual fire weather shifts), which would allow wildfires more opportunity to physically join otherwise discrete disturbed patches before going out?

Many thanks to Mistik Management Ltd., the Saskatchewan Forest Centre, and Saskatchewan Environment for the use of their data for this Quicknote.

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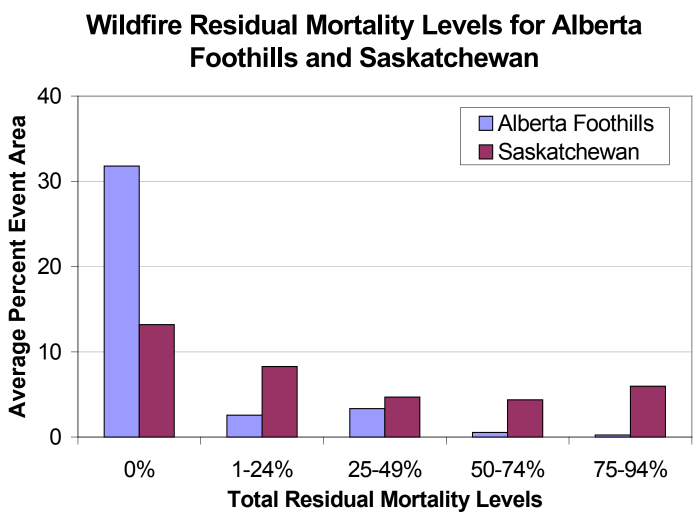
Natural Disturbance Program Quicknote #44

April 2008

By: David W. Andison

Residual Survival Levels: Alberta Foothills vs. Saskatchewan

We already know from Quicknote #41 that wildfires in Saskatchewan and Alberta Foothills have similar levels of total residuals (island remnants + matrix remnants). However, survival levels of those residuals for each landscape are fairly distinctive.



Out of a possible 38% by area in residuals in the average Alberta Foothills wildfire, over 31% survive intact. Only a fraction (0.8%) of the area of Foothills wildfire events is in residuals with more than 50% mortality. In contrast, of the 36% of the area in residuals in the average Saskatchewan wildfire, only 13% survives intact, compared to 11% that survives in residuals with greater than 50% mortality (see adjacent Figure).

In other words, Alberta Foothills wildfires tend leave a more obvious burn pattern of either entirely burnt or entirely unburnt vegetation, while Saskatchewan wildfires tend to be more transitional in severity.

This suggests that wildfires in the Alberta Foothills tend to be more spatially abrupt; harder edges, and thus more patchy. Recall that Quicknote #43 concluded that Alberta Foothills wildfires had significantly more disturbed patches relative to Saskatchewan wildfires.

But why would wildfires in the Alberta Foothills be so much less likely to have partially burnt areas? One possible explanation is the difference in fuel types. Saskatchewan tends to have a far greater proportion of (hardwood and softwood) mixed stands and a moderate proportion of non-treed wet areas. The Alberta Foothills landscape is dominated by (more flammable) dense pine and spruce. Saskatchewan also has more subtle terrain compared to the Alberta Foothills. As one can imagine, significant topographic features will influence fire movement.

Another possible explanation is differences in fire weather. As already discussed in Quicknote #43, the weather may be more likely to undergo sudden and significant shifts in the Alberta Foothills, which may translate into (more) sudden changes in fire behaviour – which may manifest itself as a patchy burn pattern.

On a final note, consider that if one adopted a more conservative definition of a residual, the residual levels of the two landscapes would be significantly different. For example, by ignoring any areas with greater than 50% mortality, Alberta Foothills wildfire events would still average 37% residuals by area, but now the average Saskatchewan wildfire will only have 26% residuals by area. While there is no *right* way to conduct or summarize natural pattern research, there are clearly management-related consequences of those choices.

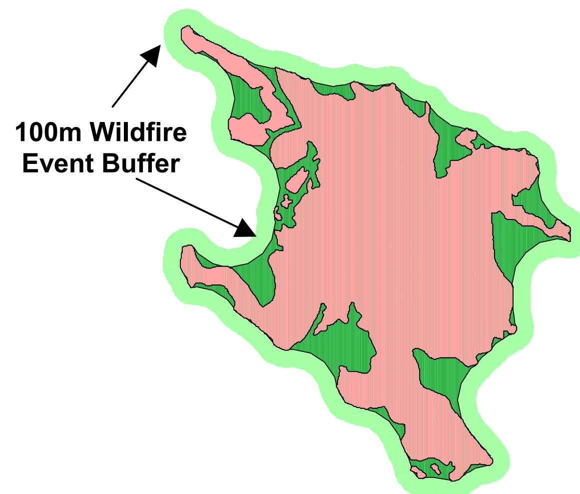
Many thanks to Mistik Management Ltd., the Saskatchewan Forest Centre, and Saskatchewan Environment for the use of their data for this Quicknote.

For more information on ND Quicknotes, please contact: Dr. David Andison, Bandaloop Landscape Ecosystem Services, Tel.: (604) 225 – 5669, Email: andison@bandaloop.ca, or visit www.foothillsresearchinstitute.ca

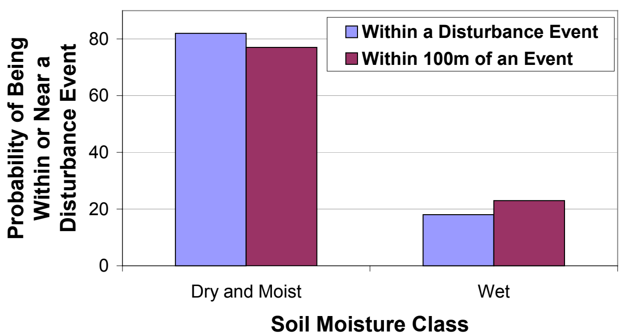
July 2008 By: David W. Andison

Are Natural Wildfire Event Boundary Locations Random?

Yes and no. The buffer zone just beyond the boundaries of a wildfire in west-central Alberta (shown in light green in the adjacent Figure) have wetter soils, smaller trees, more hardwood leading forest, and more treeless areas than the surrounding landscape.



For example, all things being equal, one would expect the proportions of soil moisture conditions within the buffer of a wildfire event to be similar to the proportions of soil conditions within the event itself. In contrast, our research reveals that areas with 'wet' soil conditions occur 18% of the time within a disturbance event, compared to 23% of the time within the 100m buffer around a disturbance event.



These burning tendencies are consistent with those noted for matrix remnants from Quicknote #31. The findings are also consistent with traditional wisdom that dense, dry conifer-dominated forested areas are more likely to burn than young, hardwood leading forest or wet areas.

Perhaps an even more revealing aspect of this analysis is its nature. The vegetation and soil conditions immediately inside wildfire event boundaries are not significantly different than those immediately outside that boundary. Only when the analysis is expanded to compare the entire event area against an external buffer (100m in this case) are differential patterns noted.

This is an excellent reminder that fire is a chemical reaction, responding to fuel type changes over both space *and* time. For example, imagine a wildfire burning at night under high humidity and no wind. The transition from a south facing conifer-dominated slope to a shrub-dominated wetland may be enough to halt the advance of the fire at or near the boundary between the two vegetation types. Now imagine the same area burning mid-afternoon under low humidity and favourable wind conditions. Although a wetland may slow the fire down, it is now more likely to burn well beyond the fuel-type boundary. In other words, when fuel conditions change, it can sometimes takes time - and space - for a fire to respond.

Implications: First, understanding this dynamic helps us formulate better research questions. Second, we can also now add the concept of an "event boundary zone" to our new spatial language. And lastly, stand-type boundaries are imperfect surrogates for disturbance event boundaries. Wildfires reshuffle the landscape mosaic in more complex ways than we imagine.

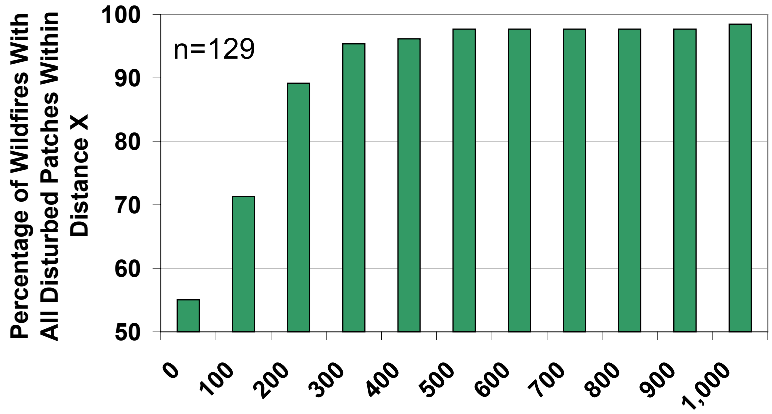
Natural Disturbance Program Quicknote #46

October 2010 *By: David W. Andison*

Patchy Fires and Spotty Behaviour

In the boreal forests of Alberta and Saskatchewan, only 55% of the naturally occurring wildfires create a single disturbed patch. The other 45% have two or more disturbed patches some distance from each other.

Percent of Alberta and Saskatchewan Wildfires With All Disturbed Patches Within 0-1,000m

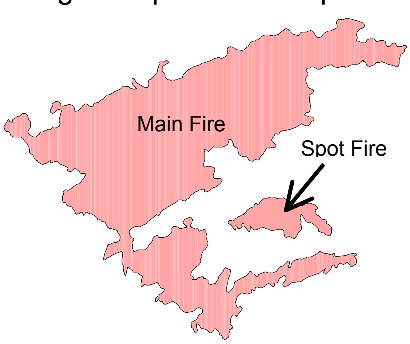


The disturbed patches of 71% of wildfires are within 100m of each other, 89% within 200m, and 94% within 300m. Ninety eight percent of the wildfires have all of their disturbed patches within 500m. Only 1.6% of all wildfires have disturbed patches further than 1,000m from the main fire.

The most likely cause of this observed spatial pattern is fire "spotting" – live fire embers that are carried via prevailing winds to ignite a new fire some distance ahead of the main fire.

These fire pattern results are consistent with what little is known about spot fire behaviour. The available evidence in the boreal forest suggests that spotting distances of 100-300m are common, and that spotting beyond 1km is rare, and associated with extreme fire behaviour.

From a process perspective, this agreement between fire behaviour and fire pattern results is revealing. Fire patterns are not the equivalent of fire spotting. In the adjacent fire outline, let's say the ignition point of the spot fire was 500m from the main fire. After burning for another day before a fire-ending event (such as rain), the two fires are now only 100m apart. If the fire had burnt for another day, the two would likely have merged. So fire patterns do not necessarily tell us anything specific about spotting behaviour.



However, fire patterns do provide some new insight about the probably lower boundaries of spotting behaviour. For example, our data suggests that <u>*at least*</u> 45% of all historical wildfires in Alberta and Saskatchewan produced spot fires. Similarly, <u>*at least*</u> one out of every 62 (1.6%) of all historical wildfires generated spotted fires beyond 1,000m.

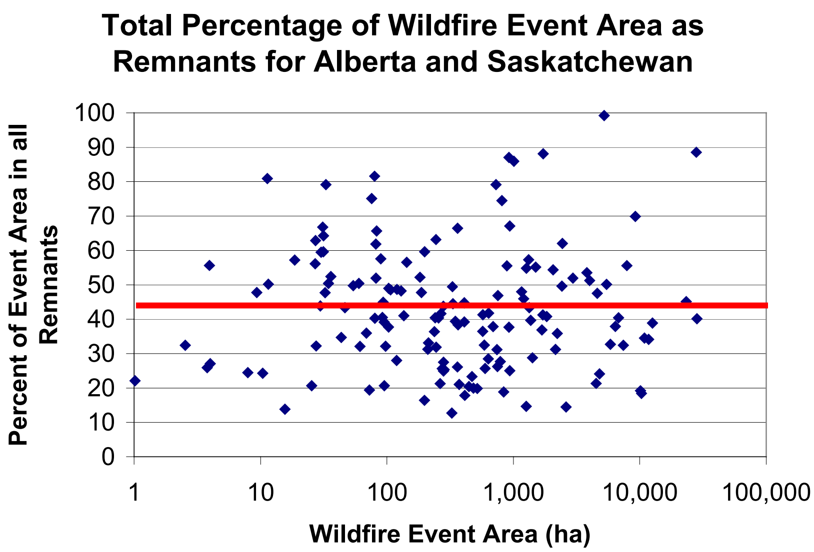
From a pattern perspective, these findings suggest that our understanding, language, and investigations of disturbance patterns need to go beyond individual disturbed polygons to the spatial relationship between disturbed polygons in time and space. This is particularly critical if we plan on using such knowledge to help guide cultural disturbance activities. Thus, the relative locations and spacing of harvest blocks or prescribed burns are at least as important to consider as the disturbance patterns within each of those blocks or burns (for more information on *disturbance events*, see Quicknotes #7, 10, & 22).

For more information on ND Quicknotes, please contact: Dr. David Andison, Bandaloop Landscape Ecosystem Services, Tel.: (604) 988-0985, Email: andison@bandaloop.ca

January 2011 *By: David W. Andison*

Boreal Wildfires and Landscape Diversity

The FRI ND Program recently extended its natural wildfire sampling to include another 77 wildfires from across the rest of Alberta, for a total sample of 129 fires across Alberta and Saskatchewan.



The results of this broad sample confirm observations from previous analyses.

Most notably, the total level of (island + matrix) remnants of western Canada boreal wildfires is quite high, averaging 43% by area. The amount of remnant area is also unrelated to disturbance event size.

For context, a minimum of 80% mortality (or 20% remnants) has been suggested by some as the threshold for "stand-replacing" fires. According to this rule, only 8% of all historical boreal & foothills wildfire events would qualify as stand-replacing. In contrast, 14% of western boreal & foothills wildfire events have at least 60% of their area as remnants (which translates to a maximum of 40% survival), which would qualify as stand-maintaining fires.

The expanded sample also confirmed that a range of residual levels is an inherent quality of boreal & foothills wildfires. For example:

- 25% of all wildfires have between 7-29% remnant area,
- 25% of all wildfires have between 29-40% remnant area,
- 25% of all wildfires have between 40-52% remnant area,
- 25% of all wildfires have between 52-99% remnant area.

One might conclude from this research that the ultimate goal of an NRV strategy is to move towards average remnant levels of 43%. These findings certainly challenge what we think we know about boreal forest disturbance dynamics as it relates to cultural disturbance activities.

However, this research also highlights a critical and undervalued aspect of an NRV – *variability*. Given the likely role of event-scale residual variability on landscape-scale heterogeneity, perhaps it is more important to create as much variability as possible than it is to match the long-term historical average of pattern X or Y. For example, imagine the impact of this huge variation in residual levels on fires of all sizes across millions of hectares and thousands of years. The resulting landscape-scale structural and compositional complexity is enormous. Any narrowing of that range may be more critical to maintaining ecological integrity than anything else.

Perhaps the most essential and effective NRV strategy is simply to generate diversity - at all scales.

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Bandaloop Landscape Ecosystem Services, Tel.: (604) 988-0985, Email: andison@bandaloop.ca**

Get to Know LandWeb

#1. Introducing LandWeb. What does it mean for you?

When you have fresh questions but your model is already stale

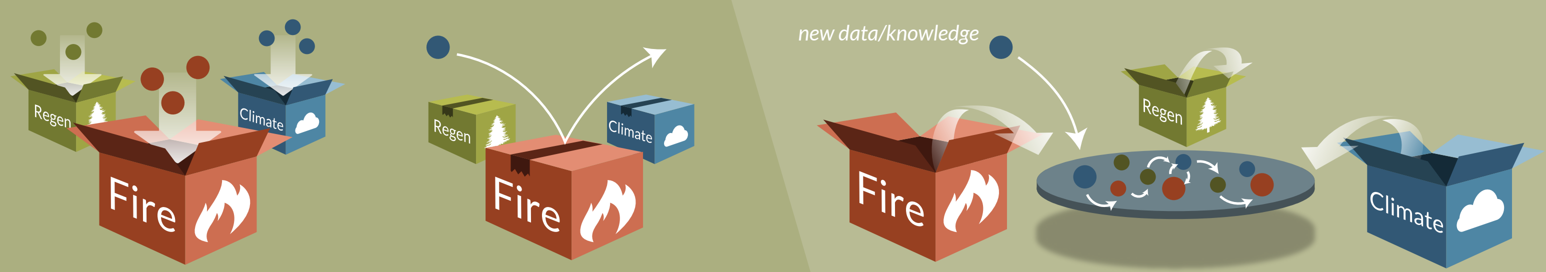
When you hear the word "model", what do you think of? For forest managers, models represent a large investment of time and effort to reliably answer a question. Models can be powerful tools, but they are only as good as the data and knowledge that go into them—which means as soon as new data is collected, the model is in danger of becoming obsolete.

The one-model-per-question approach leaves managers playing catch-up as the questions, assumptions, and data change. **There is a better way.**

Traditional models are good when first built...

... but are inflexible to new knowledge inputs.

Modern platforms are dynamic and allow models and new knowledge to integrate together.



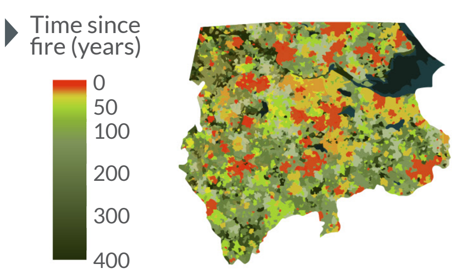
LandWeb is built on a modern platform that keeps it flexible, dynamic, and integrative.

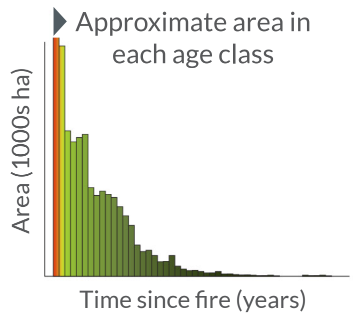
LandWeb keeps you up-to-date and takes you straight to the results

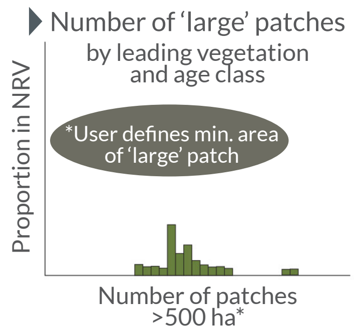
Moving beyond individual models is not a simple task, and that's just the first step. When it comes to understanding a landscape's natural range of variation (NRV), LandWeb combines models for you and takes you straight to the results.

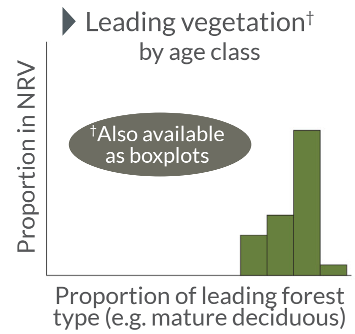
LandWeb is an easy-to-use web application that allows managers to visualize the landscape's NRV with a few clicks of the mouse. It does this by breaking away from the traditional one-question-one-model framework, allowing for continual updates as new information become available. It combines several sources of public and proprietary data, and the supporting components that form the basis of LandWeb have been peer-reviewed and validated.

LandWeb users get the following information by ecozone, FMA, or (for registered users) custom polygons:









LandWeb is part of a larger framework built for complex challenges in a changing, interconnected world

LandWeb is built within the SpaDES (Spatial Discrete Event Simulation) modelling platform, which gives it the flexibility to be updated without starting from square one. But the LandWeb app is just the tip of the iceberg for understanding complex ecological management problems.

The LandWeb app offers a simple and powerful interface for users to view NRV output from the LandWeb model.

The LandWeb model is a configuration of SpaDES components—known as "modules"—specifically designed to address NRV questions.

SpaDES has reimagined how we design models to answer complex questions by "unboxing" models so they can be integrated in different configurations.

The SpaDES framework not only provides the platform that allows various model components (modules) to talk to each other, but also includes different modules created by "unboxing" models developed by many different researchers. These various modules can be combined in new and different ways to answer a range of questions.

What could future expansions of LandWeb be used to answer?

LandWeb has a specific purpose, but there is no need to stop there. The Healthy Landscape Program's mission is to ask and address a range of these pressing, intricate questions—if you have questions and want to know if they can be answered through future expansions of LandWeb or SpaDES, send them to the Healthy Landscapes Program using the contact information below. Here are just a few examples of what is possible for LandWeb and SpaDES using modules that are complete or under development:

What could LandWeb answer with a minor expansion?

Pre-industrial estimates of...

... habitat condition for woodland caribou

... NRV for different habitats and landscape types (e.g., riparian and non-riparian)

... past populations of wildlife (e.g., caribou and grizzly bears)

What could future expansions using SpaDES be used to answer?

Use SpaDES to predict...

... future range of variation ("FRV") under climate change

... long-term implications of not managing the "passive" part of the boreal forest

... how future mountain pine beetle scenarios may influence wildfire threat

Visit LandWeb: landweb.ca
Learn more about SpaDES: spades.predictiveecology.org
Contact the Healthy Landscapes Program: andison@bandaloop.ca

fRI Research
Healthy Landscapes Program

quickNotes
the information note of fRI Research

fRI Research
Informing Land & Resource Management

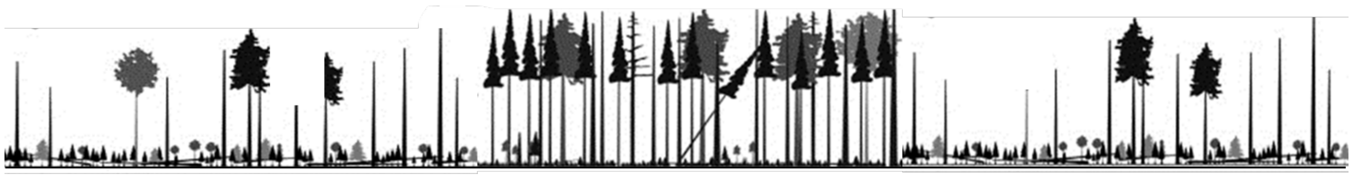
Healthy Landscapes Program Quicknote #49

January, 2020
By: David Andison

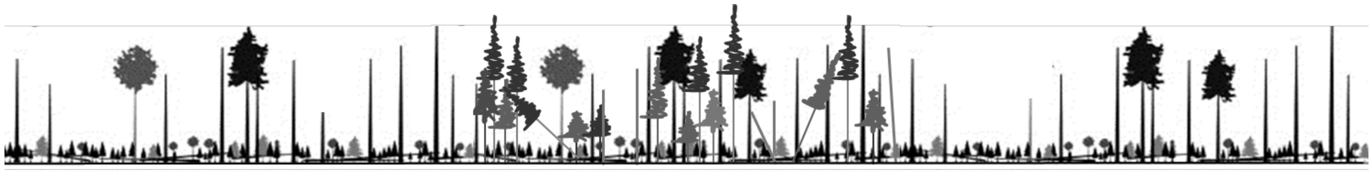
Why Wildfire Severity is Important

When used in the context of forest management, the term "severity" usually refers to tree mortality levels within a disturbance event, often manifested as a percentage of an event area in undisturbed remnants. On average, HLP research suggests that remnant patches account for 43% of the area of natural wildfire events in the western boreal. However, our research also suggests that a) that figure varies significantly over time and space, b) up to half of all remnant area has partial tree mortality, and c) of the remnants with partial mortality, most are high-survival (i.e., >50%).

Undisturbed residual



Partially disturbed residual



Partial mortality is not an attribute we tend to associate with the boreal forest. However, it offers some new and valuable insights into how the boreal functions. Consider the immediate impact of the structural diversity generated by partial mortality. Partial mortality creates structural and compositional diversity at fine scales to which many species have co-evolved. A conservative back-of-the-envelope calculation suggests that an estimated 15-20% of the western boreal landscape that was technically multi-aged at any given point in time historically.

Consider the potential biological implications of this.

1) Definitions of "old growth" in the boreal may need to be reconsidered. "Old growth" is not the same thing as "old forest", which is defined simply by the number of years since the last disturbance.
2) Associated habitat research and modelling must account for multi-aged stands going forward. For example, the inclusion of partial mortality in research and modelling of woodland caribou is likely to reveal new lessons.
3) Habitat models that assume single, simple age structure (e.g. woodland caribou) may need to be reconsidered. Without including partial mortality, some habitat types will become rare, landscapes simplified, and the ecosystem less sustainable and resilient.

In the end, this seemingly subtle change in our understanding of how the boreal ecosystem works from a fire regime perspective is fundamental to our understanding of the sustainable delivery of ecosystem health and resilience in general, and that of many critical values more specifically.

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Healthy Landscapes Program Quicknote #50

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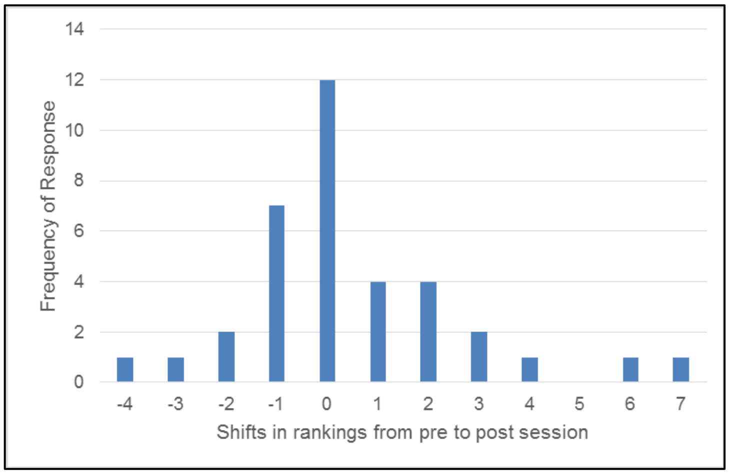
What is EBM? *It Depends*

At its heart, The Healthy Landscapes Program is about exploring, understanding, demonstrating, and sharing if / to what degree the principles of Ecosystem-Based Management (EBM) might apply to the management of forested landscapes in Canada. A significant undertaking—made even more challenging by the range of interpretations and definitions of EBM.

To demonstrate this particular challenge, the HL Program conducted a series of four EBM dialogue sessions across Alberta in 2017 specifically including all partner and stakeholder groups. The purpose of these sessions was not to educate, but rather to create a safe environment for sharing one's and listening to other's stories and perspectives on EBM. We coupled these sessions with surveys of the participants before and after each session.

The results proved valuable in many ways. Perhaps the most poignant output was our survey question on the value of EBM. More specifically, the question asked was "*On a scale of 1 to 10, how likely are you to recommend to a colleague EBM as a forest management approach? (one being lowest)*". Our first surprise was how widely the idea of EBM was supported. On a scale of 1–10, the average score before each session was eight, and no one ranked it less than a five.



Our second surprise was how individual rankings changed before *vs*. after each session. Only 33% of those who responded to the survey did not change their answer to this question after their respective EBM sessions. Another 36% increased their ranking, and 31% lowered it.

So: What were the findings of the EBM dialogue sessions? We clearly heard broad and deep support for the idea of EBM across all partners and stakeholders. This is encouraging news for the HLP—and those in support of EBM ideals. However, at the same time, we also heard that this support was tempered by specific interpretations of EBM. More specifically, the 31% who lowered their ranking for this question after their dialogue session were responding largely to the realization that *THEIR* interpretation of EBM was not shared by everyone else. In other words, while we may generally agree that EBM is a good thing, we must acknowledge that it means different things to different people.

The EBM dialogue sessions offered several valuable insights to the HLP and anyone else interested in testing and adopting EBM principles. First, do not assume that your particular version of EBM is a) the right one, b) universally understood or, c) universally agreed upon. Second, make space and time to hear others express their version of EBM. Whether or not agencies agree on definitions is far less important than understanding the range of perspectives. Lastly, accept *but also expect*, that whenever agency or organization uses the term, or claims to be doing EBM, it should be accompanied by a clear definition. It matters less whether it is right, but rather that it is clear and concise.

Stay tuned for the next HLP Quicknote for the HLP definition of EBM!

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