Examining effects of landscape mosaics, fuel type, and management on fire spread and behavior in northern Wisconsin, USA using modeling approach

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http://research.eeescience.utoledo.edu/lees/research/jfsp/index_files/slide0001.htm

Chequamegon National Forest, WI

- Land/Cover
- Boundary (map_JPG, GIS)
- Elevation (map_JPG, GIS)
- Slope in degree (map_JPG, GIS)
- Aspect (map_JPG, GIS)
- Stand_age (map_JPG, GIS)
- NDVI_2001 (map_JPG, GIS)
- Fuel_type (map_JPG, GIS)
- Stream (map_JPG, GIS)
- Road (map_JPG, GIS)
- Soil (map_JPG, GIS)
- Fire_info (Farsite1, Farsite2, Farsite3)
- Temperature (map, GIS)
- Precipitation (map, GIS)

Note: 15 GB space needed to unzip all 1080 climatic files (

Abstract.

*** Fire behavior and effects at landscape level were examined in CNF;

*** FARSITE (Finny 1998), 12 points, 15-day period, control landscape (2001, no harvest);

*** HARVEST (Gustafson & Crow 1996) to create management scenarios;

*** FRAGSTATS (McGarical & Marks 1995) to quantify landscape characteristics to link the fire behavior with landscape structure;

*** The averaged sizes of fire spread area in the control landscape were 2.1 (819 ha), 7.3 (2 867 ha), and 10.3% (4 038 ha) of the total, with standard deviation of 277, 752, and 979 ha, for 5-day, 10-day, and 15-day, respectively.

*** Variation in fire-spread areas (three-time folds) depending on fuel type composition, landscape structure, and fuel conductivity.

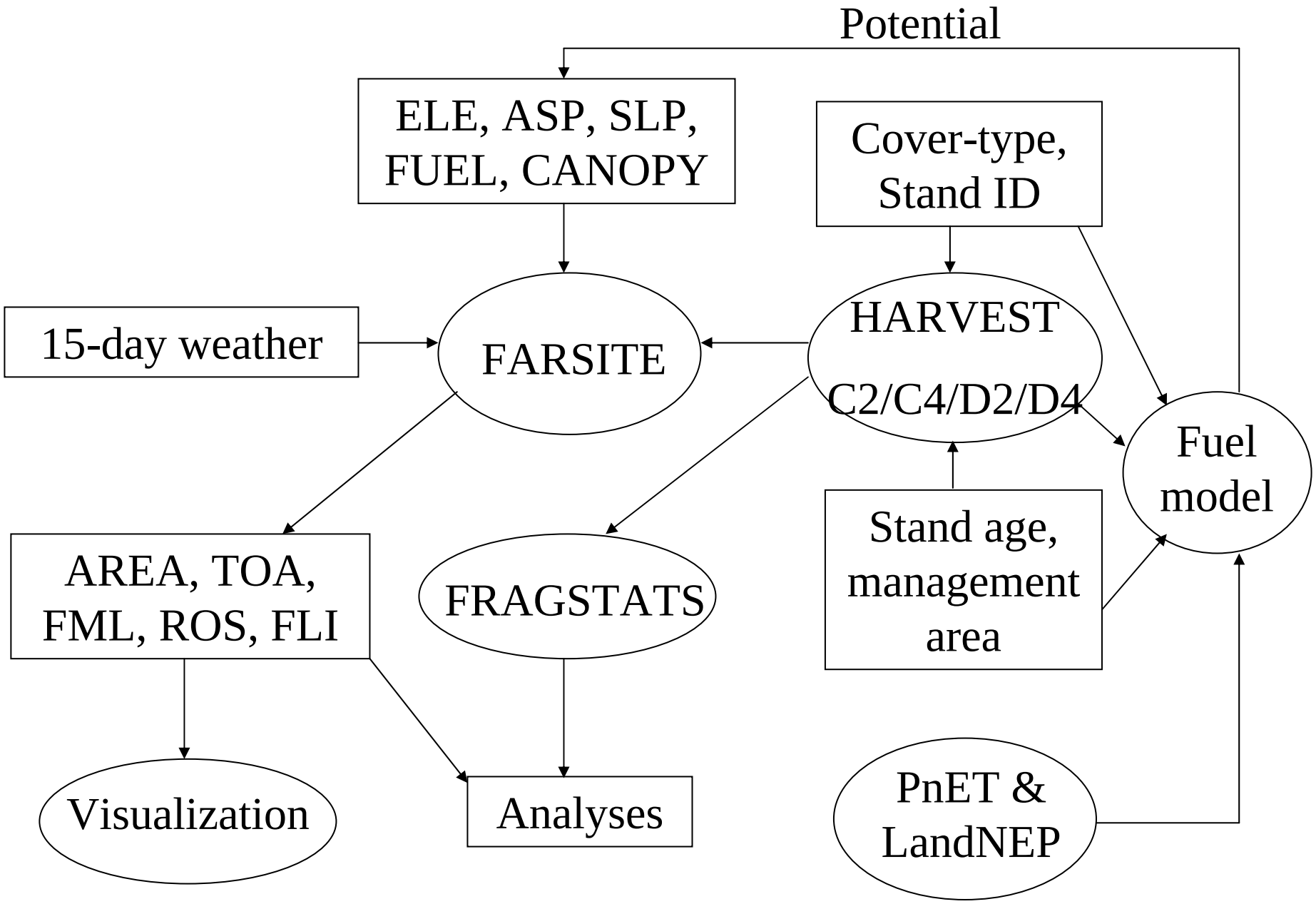
*** Clustered harvest (- 2.1% vs. –1.7% for d), (-1.4 and –2.4% for 2 and 4% harvests respectively).

Study goals

*** What are the relationships between fire spread/fuel composition and landscape characteristics?

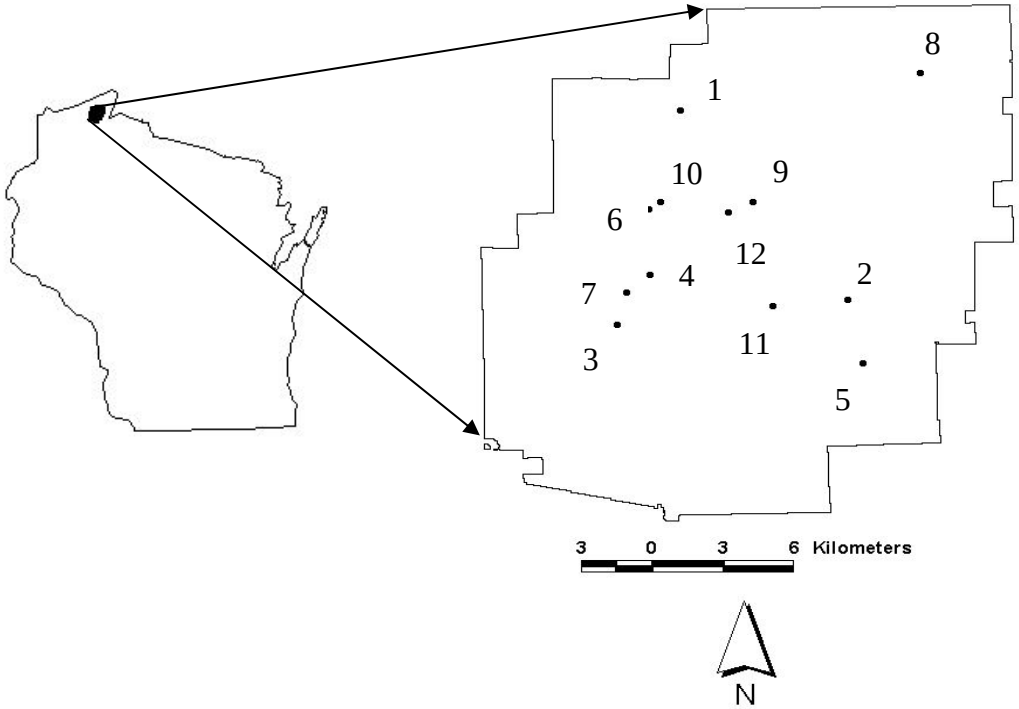
*** How does landscape heterogeneity affect fire behavior across the landscape?

*** At what degrees do different land management practices alter fire spread and behavior?


Potential
ELE, ASP, SLP, FUEL, CANOPY
Cover-type, Stand ID
15-day weather
FARSITE
HARVEST
C2/C4/D2/D4
Fuel model
Stand age, management area
AREA, TOA, FML, ROS, FLI
FRAGSTATS
Visualization
Analyses
PnET & LandNEP

FRAGSTATS is a spatial pattern analysis program designed to quantify landscape structure at various levels (e.g., patch (14), class (40), and landscape (46)) (McGarical and Marks 1995).

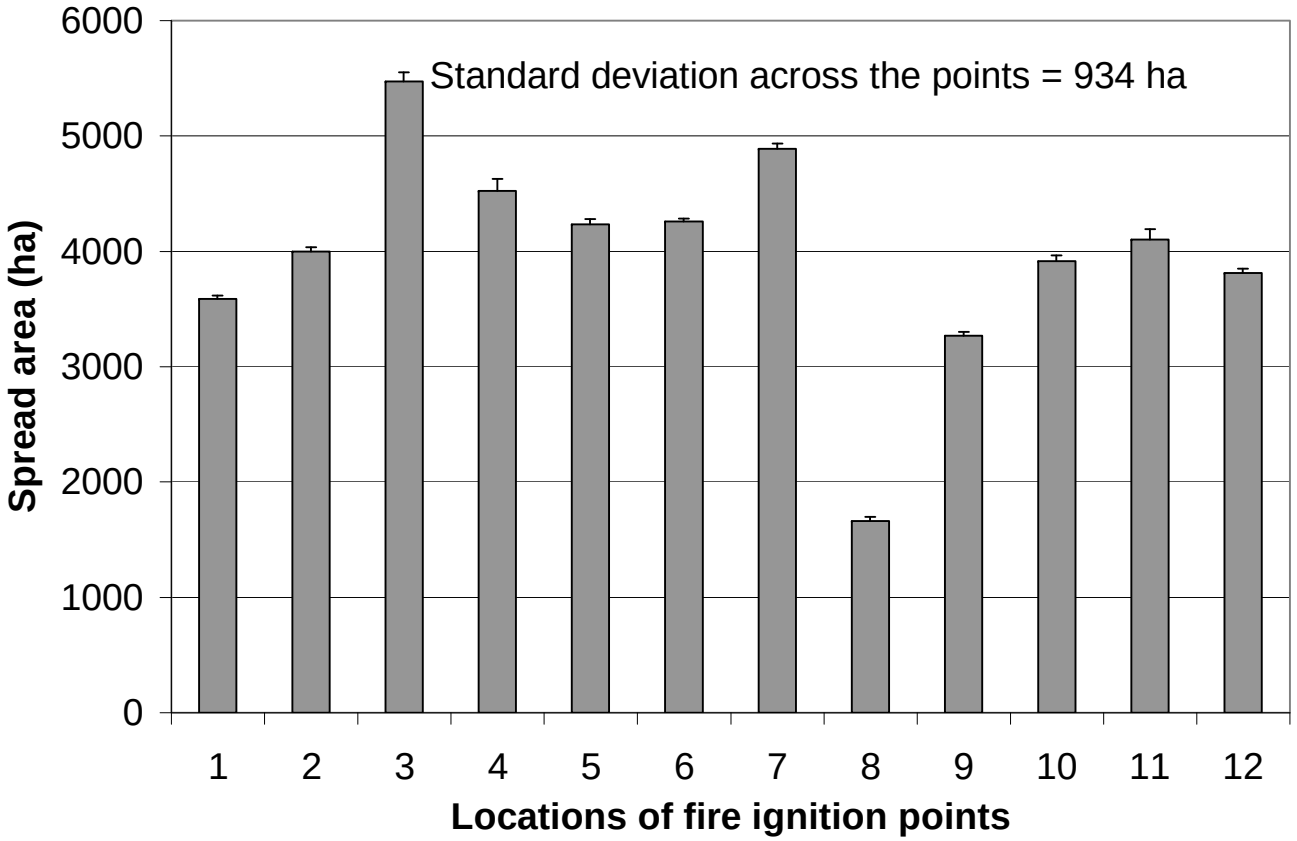
The HARVEST (Gustafson & Crow 1996) model is primarily a timber harvest simulator that was designed to evaluate alternative strategies of forest management and timber harvests and provide comparable predictions of the spatial pattern consequences of these alternative strategies.

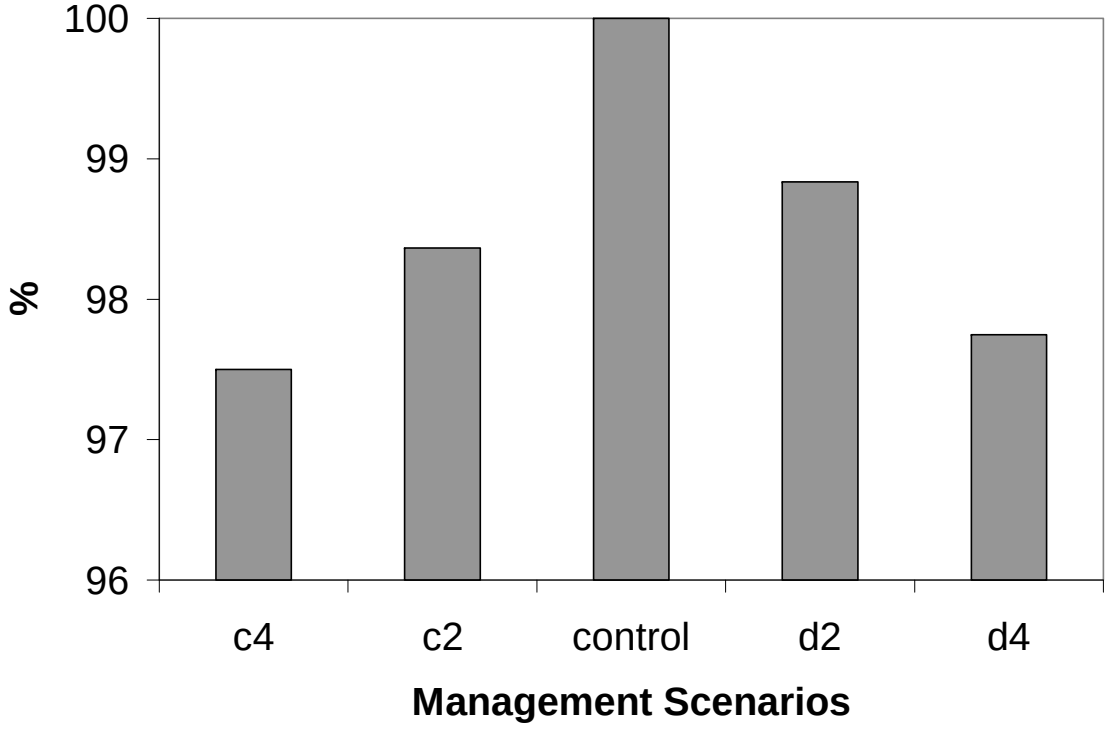

8
1
10
9
6
12
4
2
7
11
3
5
3 0 3 6 Kilometers
N

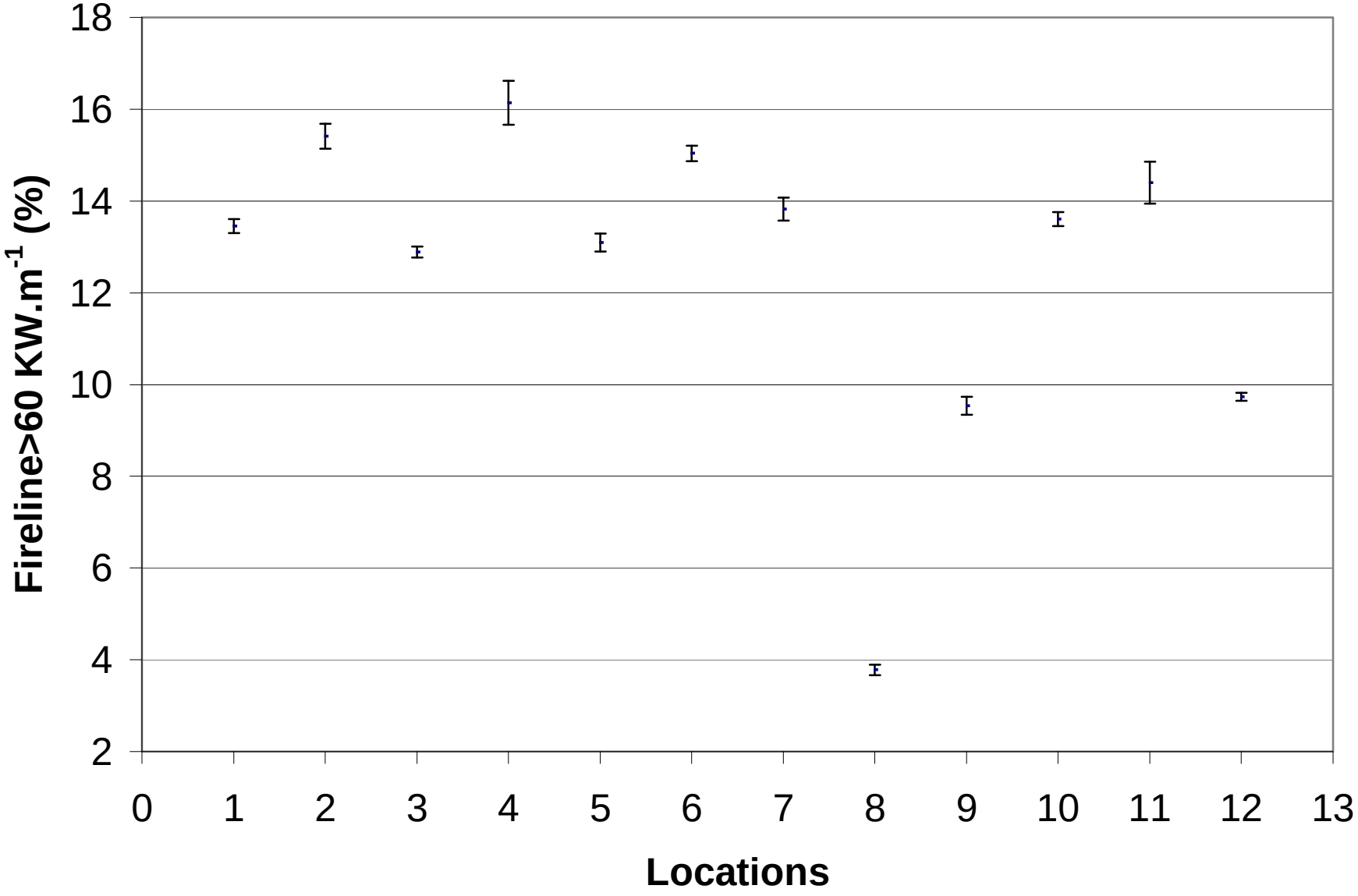
Landscape composition and characteristics within the surrounding areas of the 12 fire ignition points after a 15-day fire simulation in the control landscape. A = Brush, B = Forest litter without understory veg., C = Forest litter with understory veg., and D = Logging slash. AWMSI (Area-Weighted Mean Shape Index) = 1 when all patches in the landscape are circle (vector) or square (raster) and increases without limit as the patch shapes become more irregular.

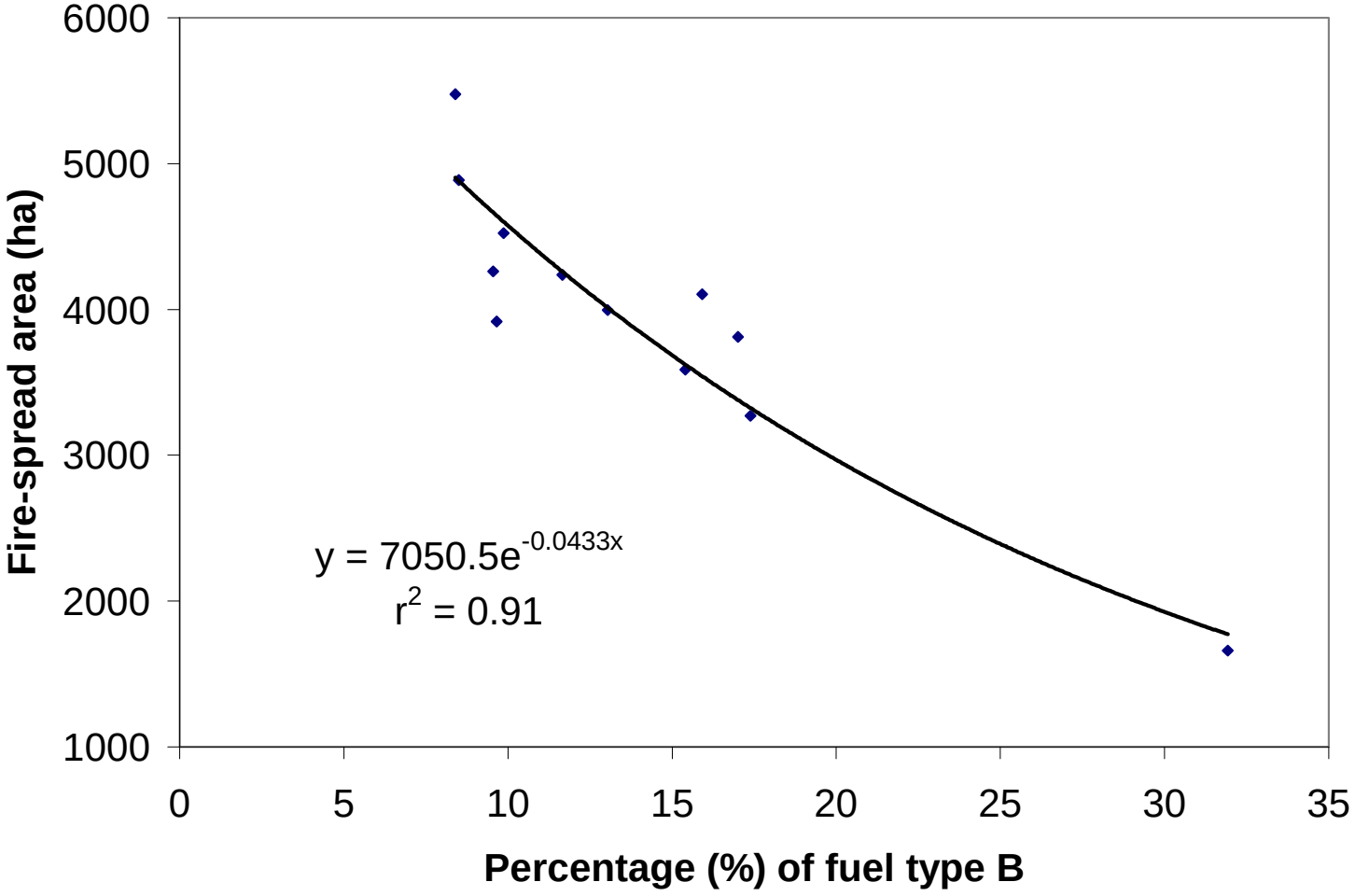
		Landscape composition and structure within burned areas					
Point	Fuel Type at the point	Dominant vegetation	Fuel A (%)	Fuel B (%)	Fuel C (%)	Fuel D (%)	AWMSI
1	A	NH	17.61	15.4	57.95	9.04	8.36
2	A	NH	20.21	13.04	59.74	7.01	9.06
3	A	JP	35.7	8.4	41.17	14.73	12.16
4	C	NH	27.88	9.87	53.09	9.16	8.63
5	C	NH	22.3	11.65	59.88	6.18	11.35
6	C	NH	13.03	9.55	67.88	9.54	9.14
7	B	JP	33.04	8.51	45.22	13.22	10.61
8	B	RP	27.65	31.92	22.81	17.62	4.09
9	B	NH	22.12	17.38	50.52	9.97	4.67
10	D	NH	14.96	9.65	64.75	10.64	8.41
11	D	NH	17.41	15.91	60.15	6.54	12.27
12	D	NH	21.12	17	51.43	10.44	6.47

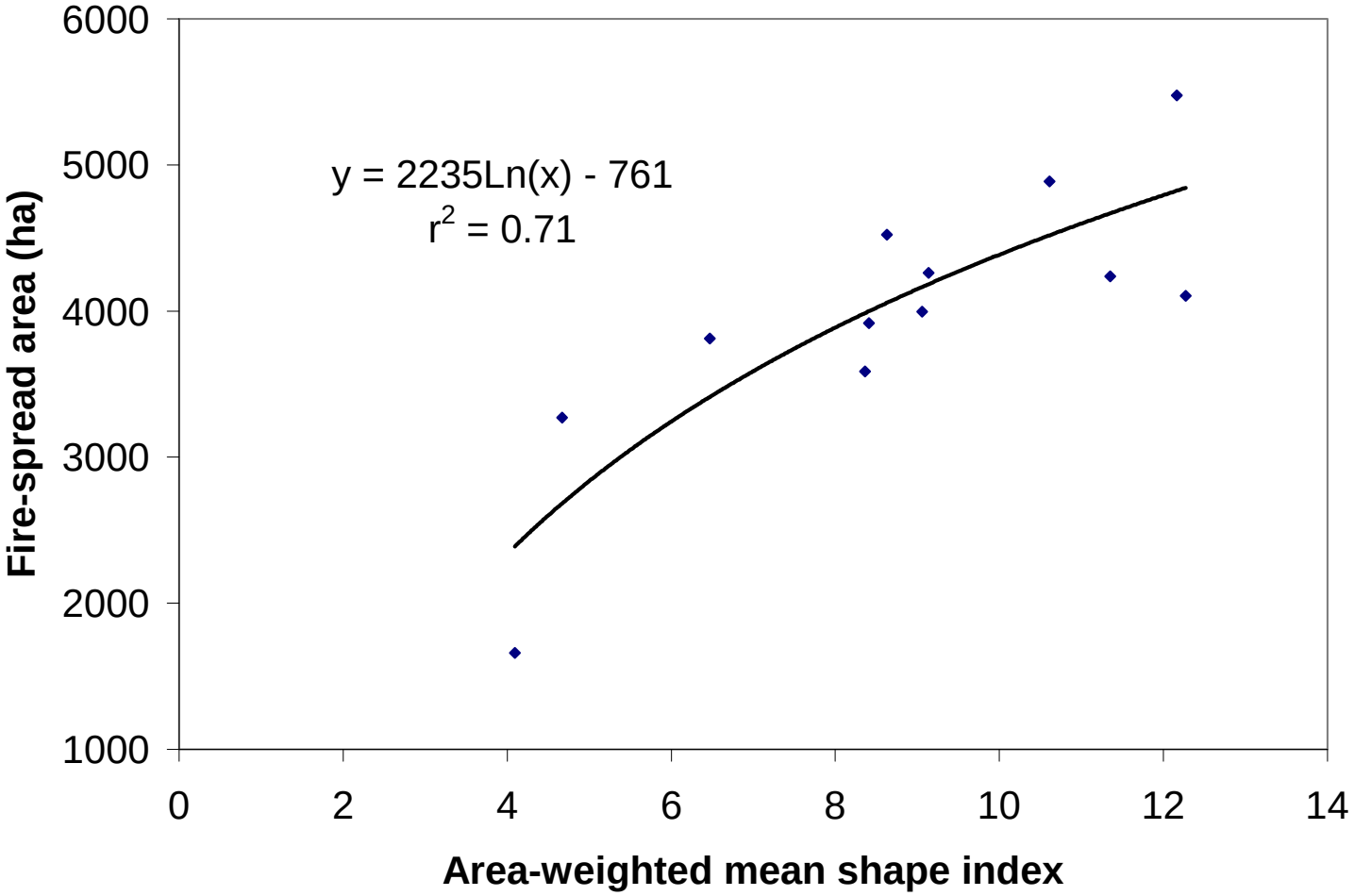
Results

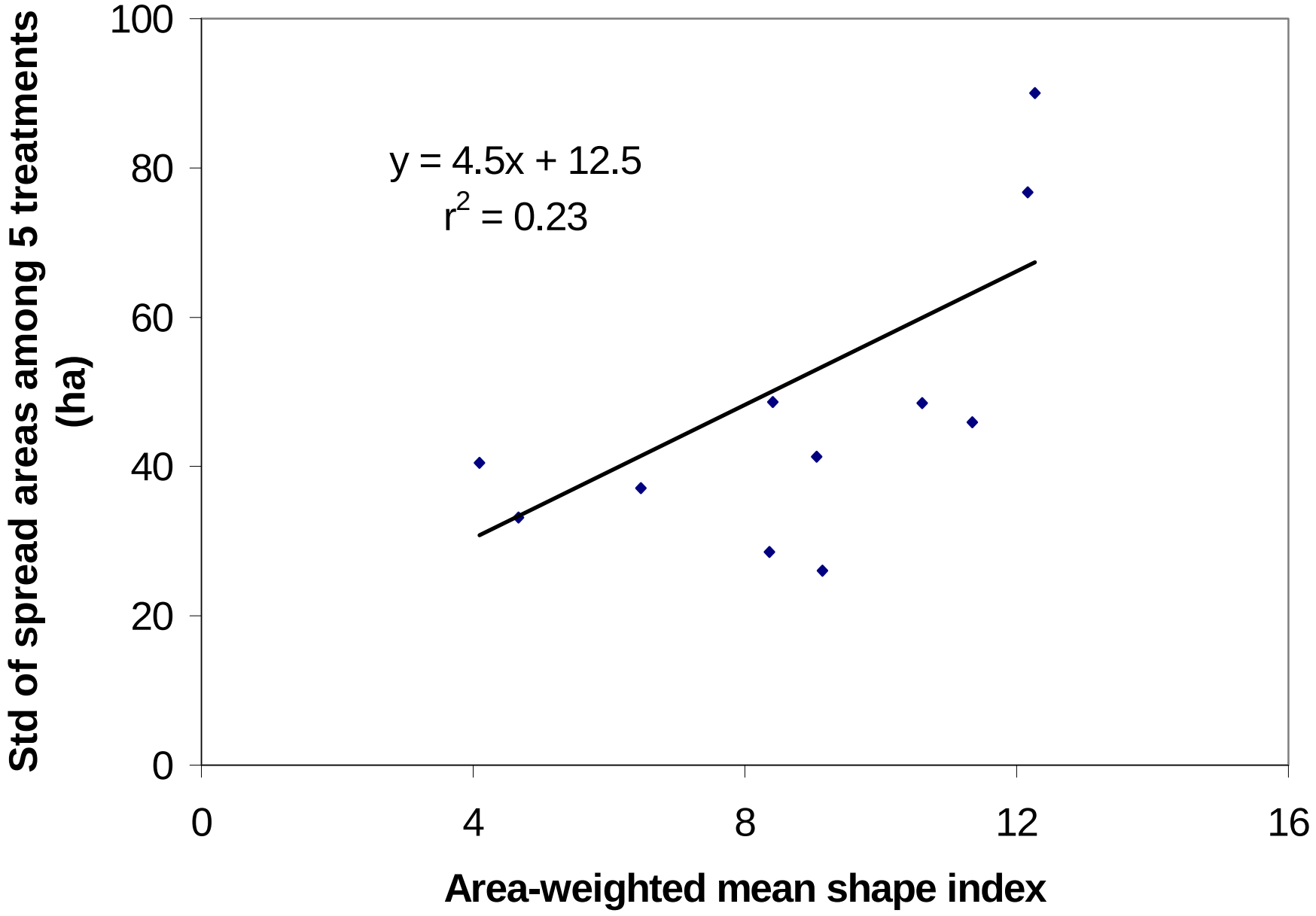

Standard deviation across the points = 934 ha
Spread area (ha)
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
Locations of fire ignition points

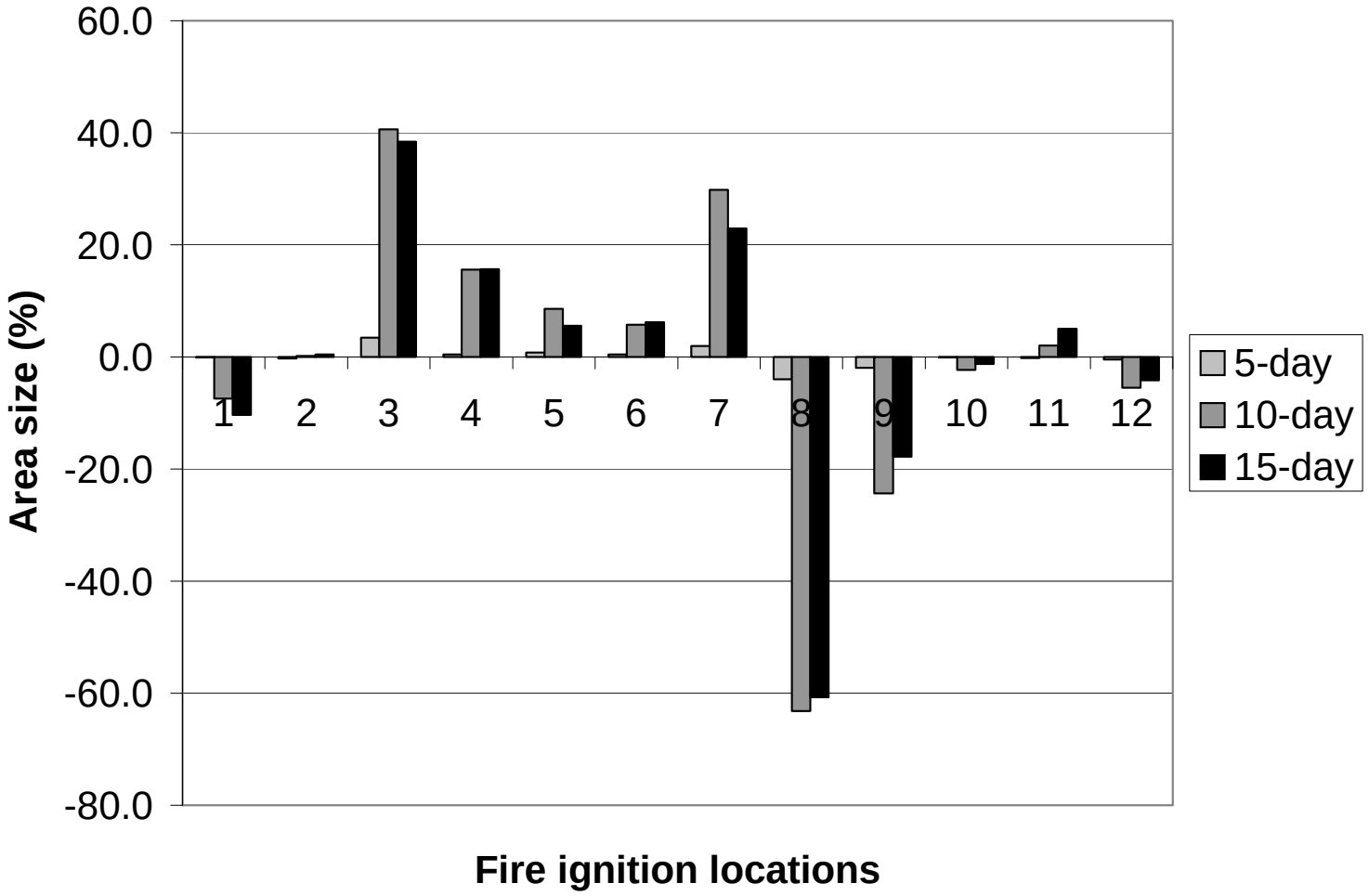

100
99
98
97
96
%
c4
c2
control
d2
d4
Management Scenarios


18
16
14
12
10
8
6
4
2
Fireline>60 KW.m-1 (%)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Locations


6000
5000
4000
3000
2000
1000
Fire-spread area (ha)
y = 7050.5e-0.0433x
r2 = 0.91
0
5
10
15
20
25
30
35
Percentage (%) of fuel type B


y = 2235Ln(x) - 761
r2 = 0.71
Fire-spread area (ha)
6000
5000
4000
3000
2000
1000
0
2
4
6
8
10
12
14
Area-weighted mean shape index


y = 4.5x + 12.5
r2 = 0.23
Std of spread areas among 5 treatments (ha)
Area-weighted mean shape index
0
20
40
60
80
100
0
4
8
12
16


60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
-80.0
Area size (%)
1
2
3
4
5
6
7
8
9
10
11
12
Fire ignition locations
5-day
10-day
15-day

Conclusion

1) Average fire spread area for a 15-day burning period consume 10.3% (or 4038 ha) of the total landscape with STD of 934 ha;

2) Spatial variation (3-fold) in fire spread areas affected by fuel type composition, landscape structure.

3) Damaged area can be reduced through managements (e.g., harvest methods, plantation of certain species)

4) Model simulation can be efficient way for achieving better fire management design. General patterns of spatial variation in fire spread across the landscape can be examined using 5-day simulations.