Fuel loads, fire regimes and post-fire fuel dynamics in Florida Keys pine forests

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The Pine Rocklands of South Florida

- Subtropical forests dominated by slash pine (*Pinus elliottii* var. *densa*)
- Globally endangered ecosystems
- Rich in flora including many endemic plant taxa.

The Pine rocklands in the Lower Florida Keys:

- Habitat of the endangered

The Pine rocklands and fire:

- Fire is important in shaping the structure and function of ecosystems.
- The endemic herb species require fire for their existence, survival, and reproduction.

Without fire:

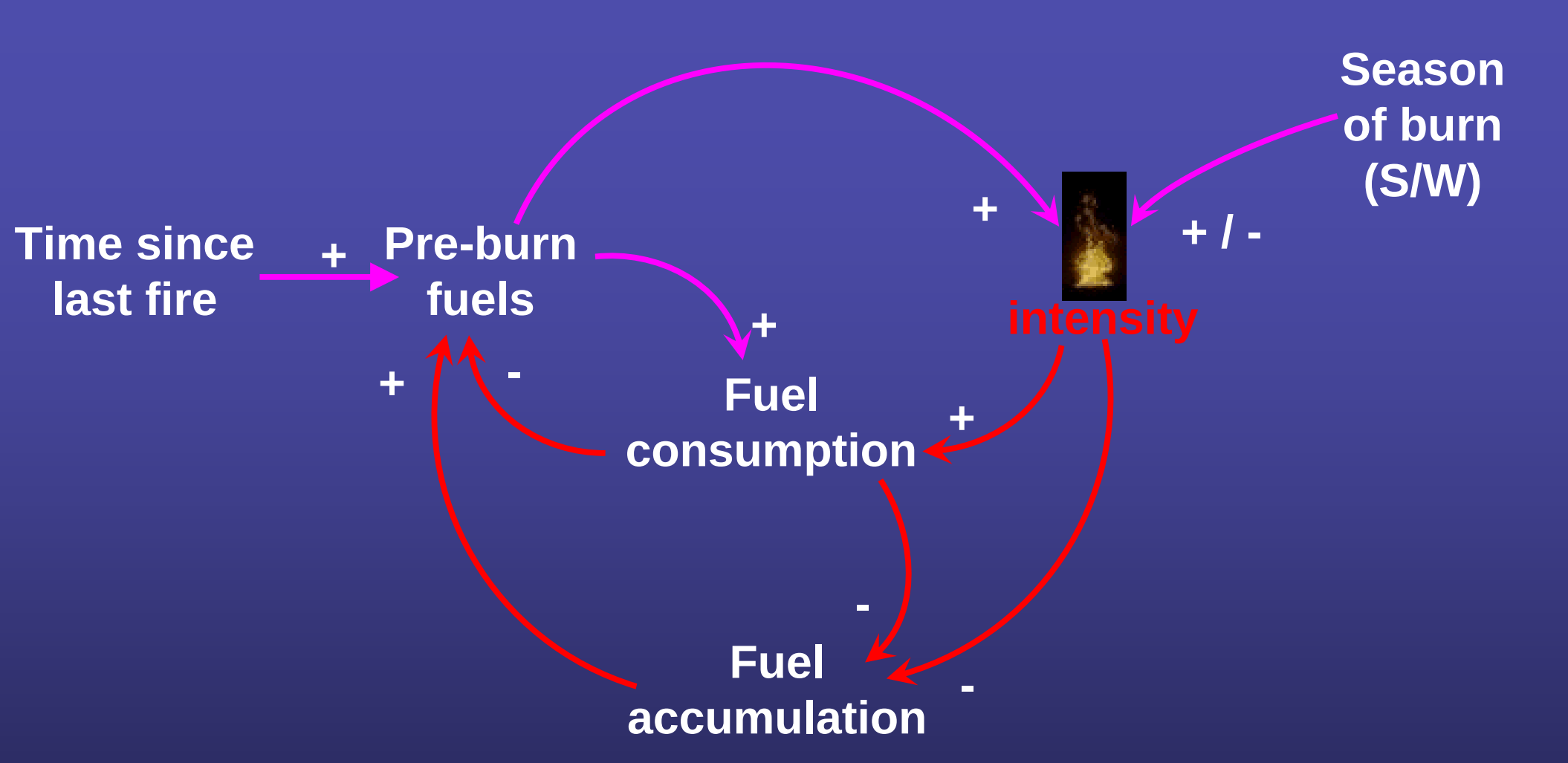
- succession towards a closed hardwood canopy
- loss of the characteristic pineland herb flora

Fire behavior depends on:

- Understory fuel types
- Season of prescribed burning
- Stand age & fuel availability

Objectives

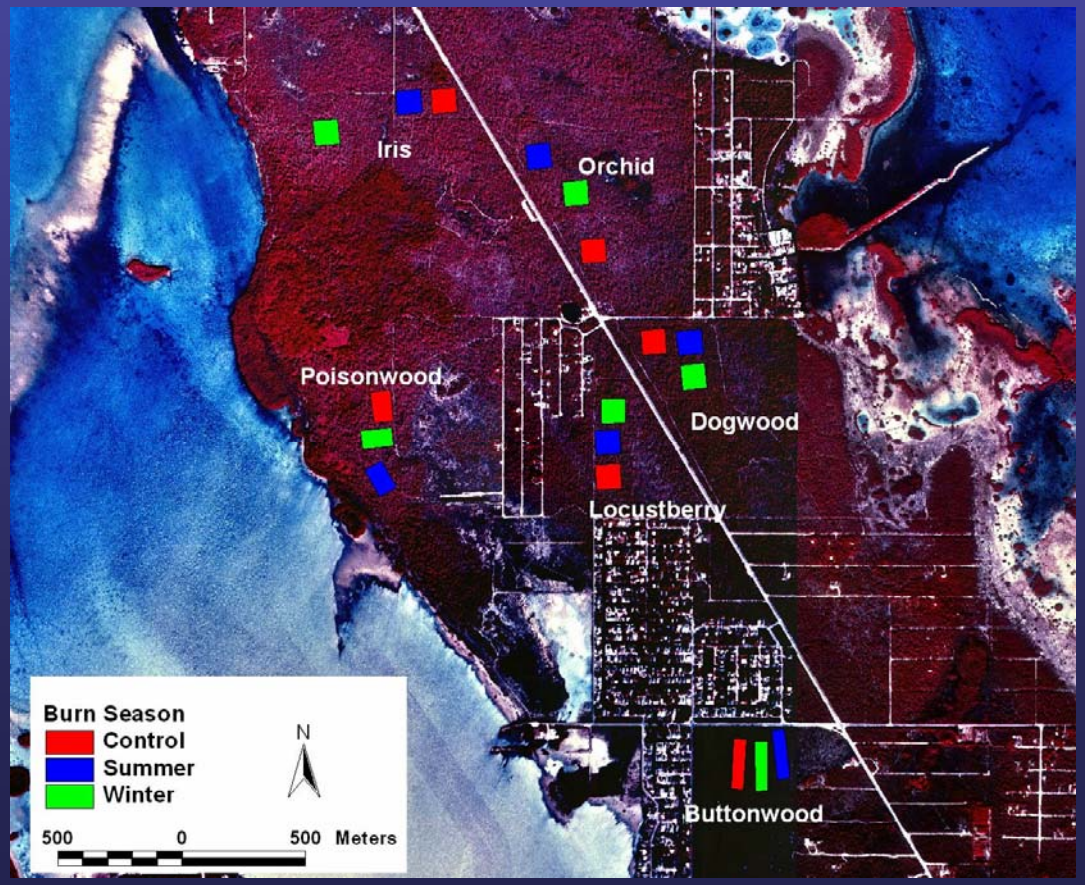
- To estimate total biomass and understory fuels in Florida Keys pine rocklands
- To examine the effects of seasons on fire intensity & fuel consumption
- To examine the dynamics of fuel accumulation after fire.



A conceptual model showing hypothetical relationships among fuel loads, fire behavior and post-fire fuel recovery

Study area & Methodology

- Fuel loads were estimated in 18 1-ha pine forest plots
- Distributed in 6 blocks (3 – Control, Summer & Winter - in each block)
  - •Five burned in different years between 1985 and 1991, and
  - •One burned prior to 1970.



Site	Years since last fire
Iris (C, S)	8
Orchid	8
Dogwood	11
Poisonwood	12
Iris (W)	14
Locustberry	14
Buttonwood	>30

Experimental burn

Plot	Intended burn year & season	Burn year/Season
OS	1998-S	1998-S
OW	1998-W	1998-W
PS	1998-S	1998-S
PW	1998-W	1998-W
IS	1999-S	1999-S
IW	1999-W	2000-W
DS	1999-S	1999-S
DW	1999-W	NB
LS	2000-S	2001-S
LW	2000-W	2001-S
BS	2000-S	2001-S
BW	2000-W	2001-S

Fire behavior

- Fire temperature
- Char height
- Scorch percent

Tree layer

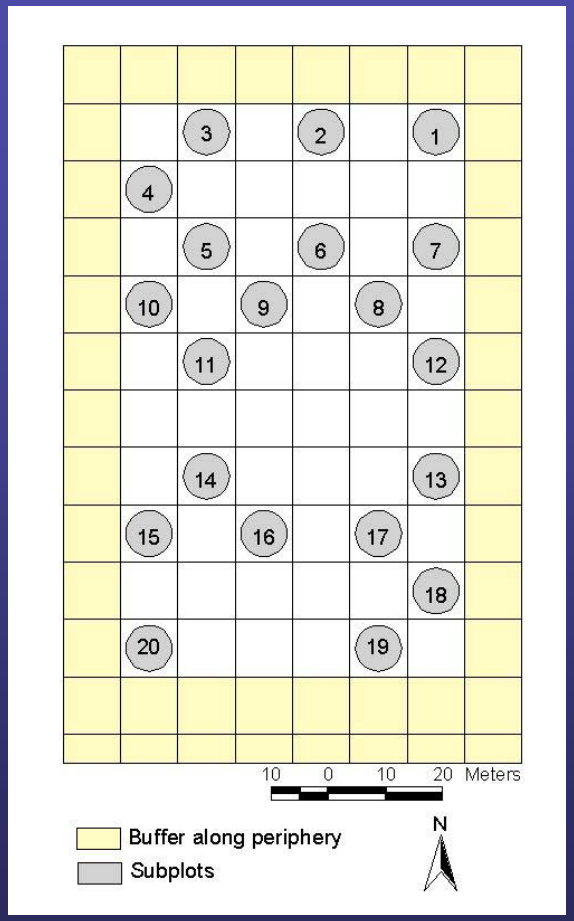
- Diameter at breast height (DBH)
- Locations (x, y co-ordinates)

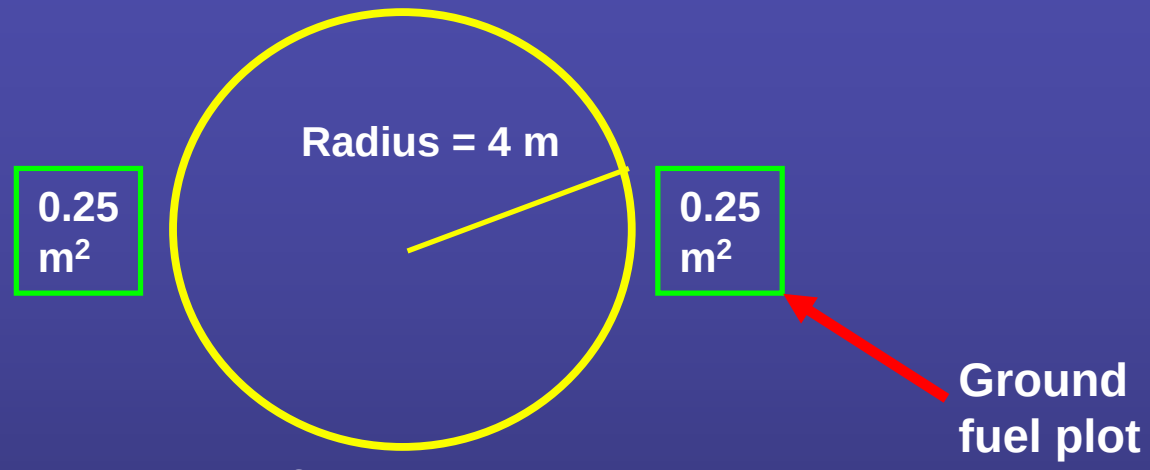
Pine tree biomass (Gholz and Fisher 1982)

HW tree biomass (Brown *et al*. 1989)

Methodology (Contd.)

Shrub and Saplings (Ht >1m, dbh <5 cm)





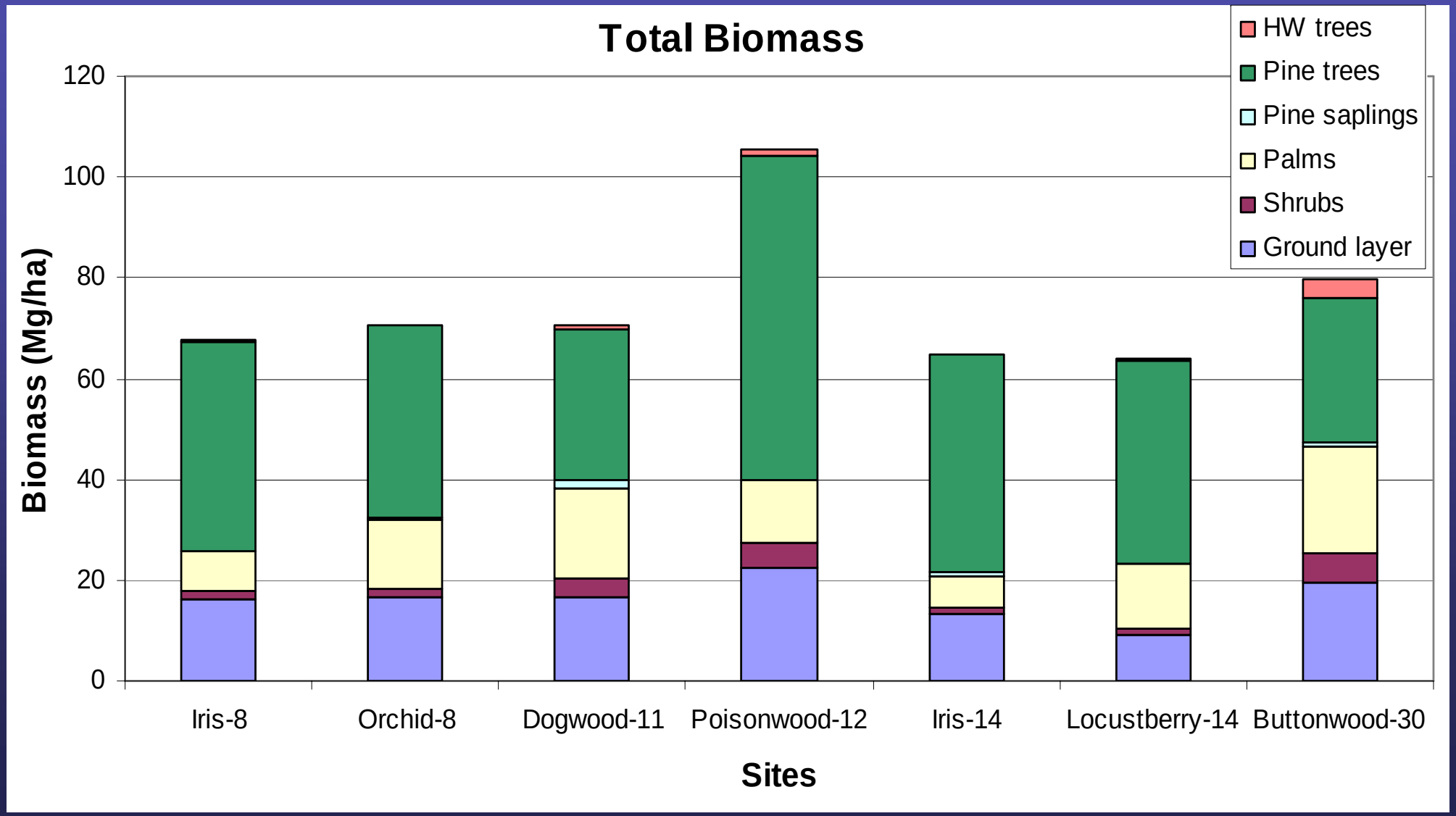
50 m^2 shrub plots

- Shrubs and Pine – allometric equations height and crown area or dbh
- Palms – Crown area and number of leaves

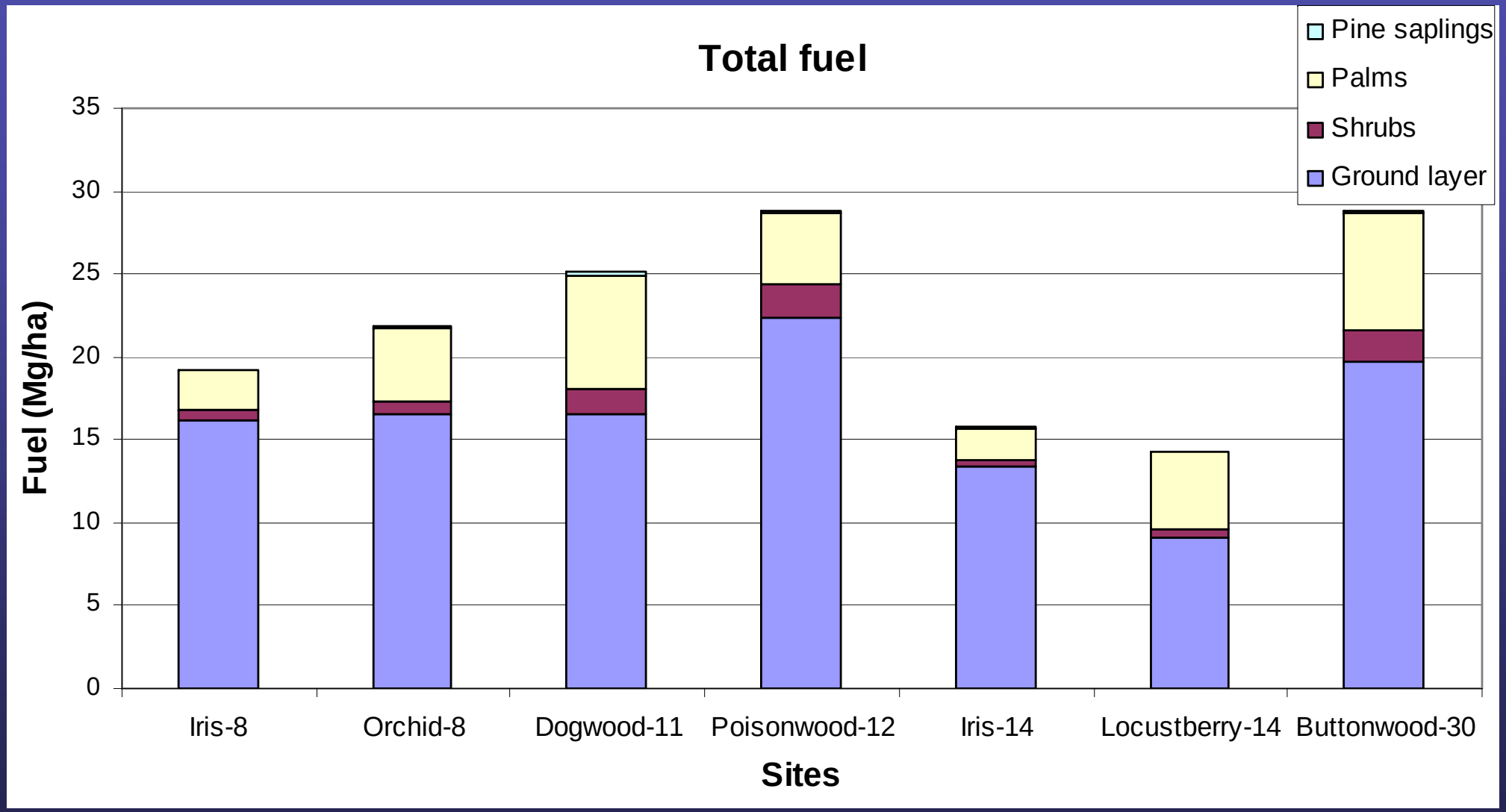
Ground layer (Height <1m)

- Harvest method

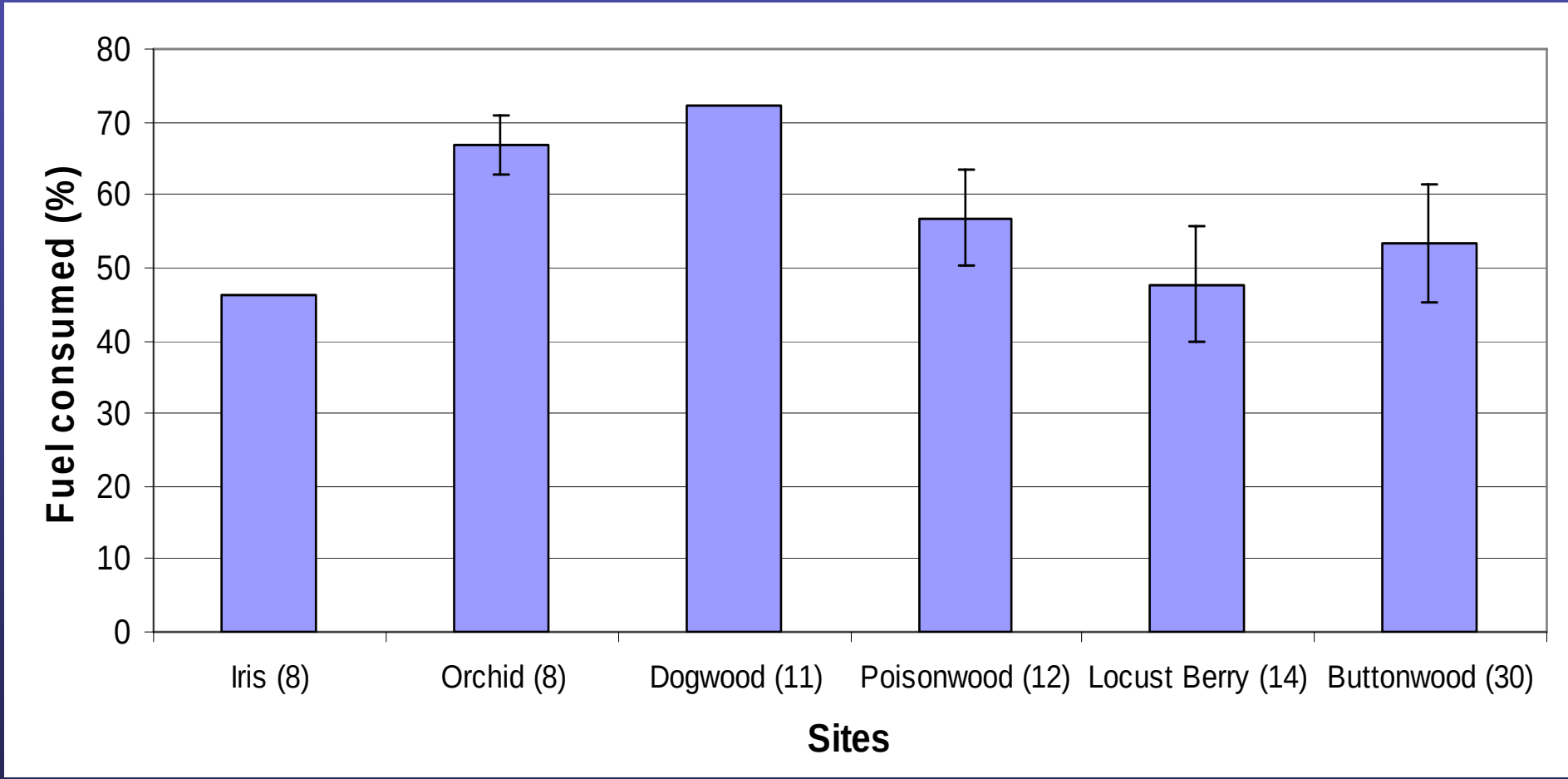
RESULTS


Total Biomass
HW trees
Pine trees
Pine saplings
Palms
Shrubs
Ground layer
Biomass (Mg/ha)
120
100
80
60
40
20
0
Iris-8
Orchid-8
Dogwood-11
Poisonwood-12
Iris-14
Locustberry-14
Buttonwood-30
Sites

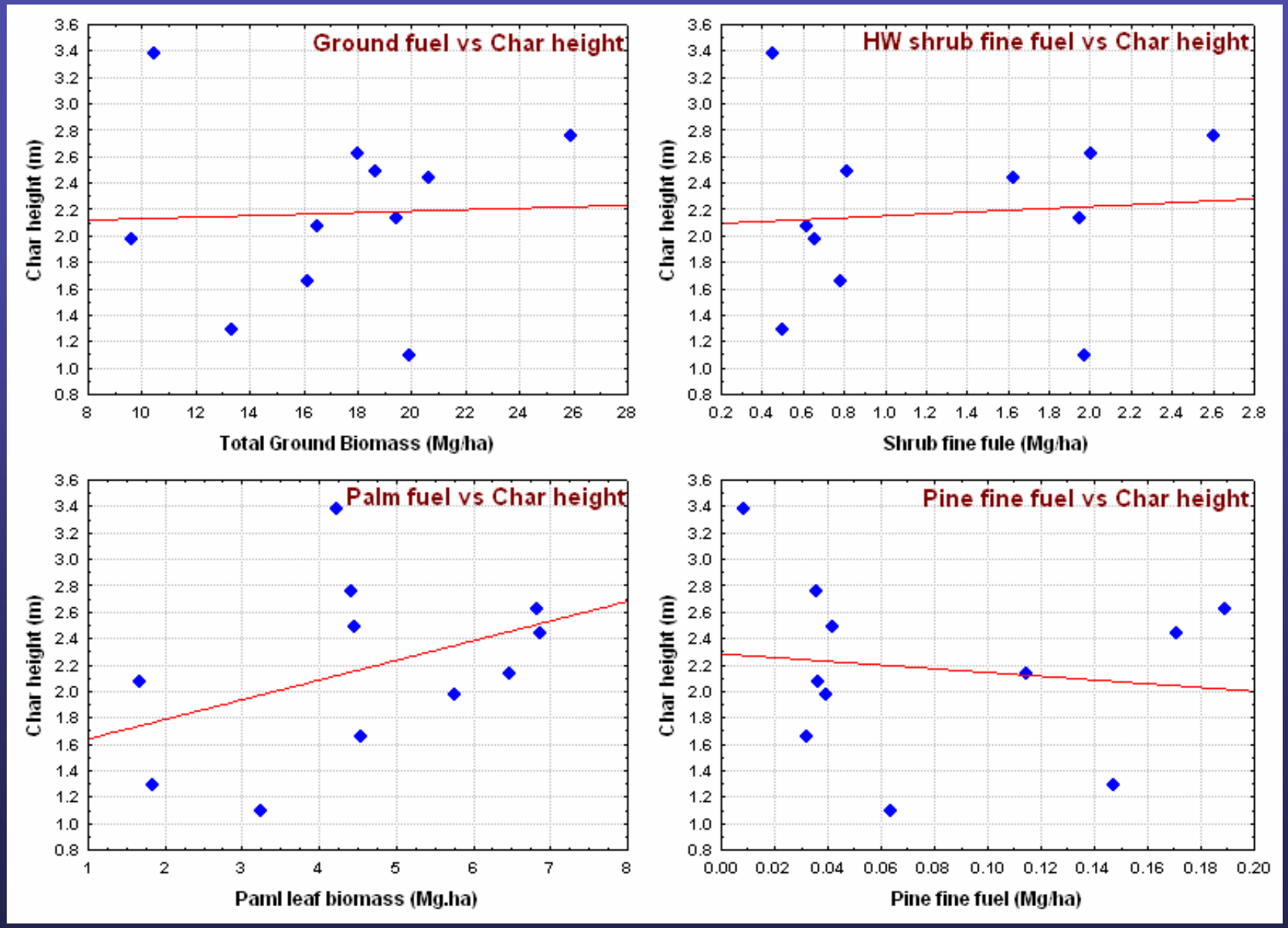
Types of Fuel



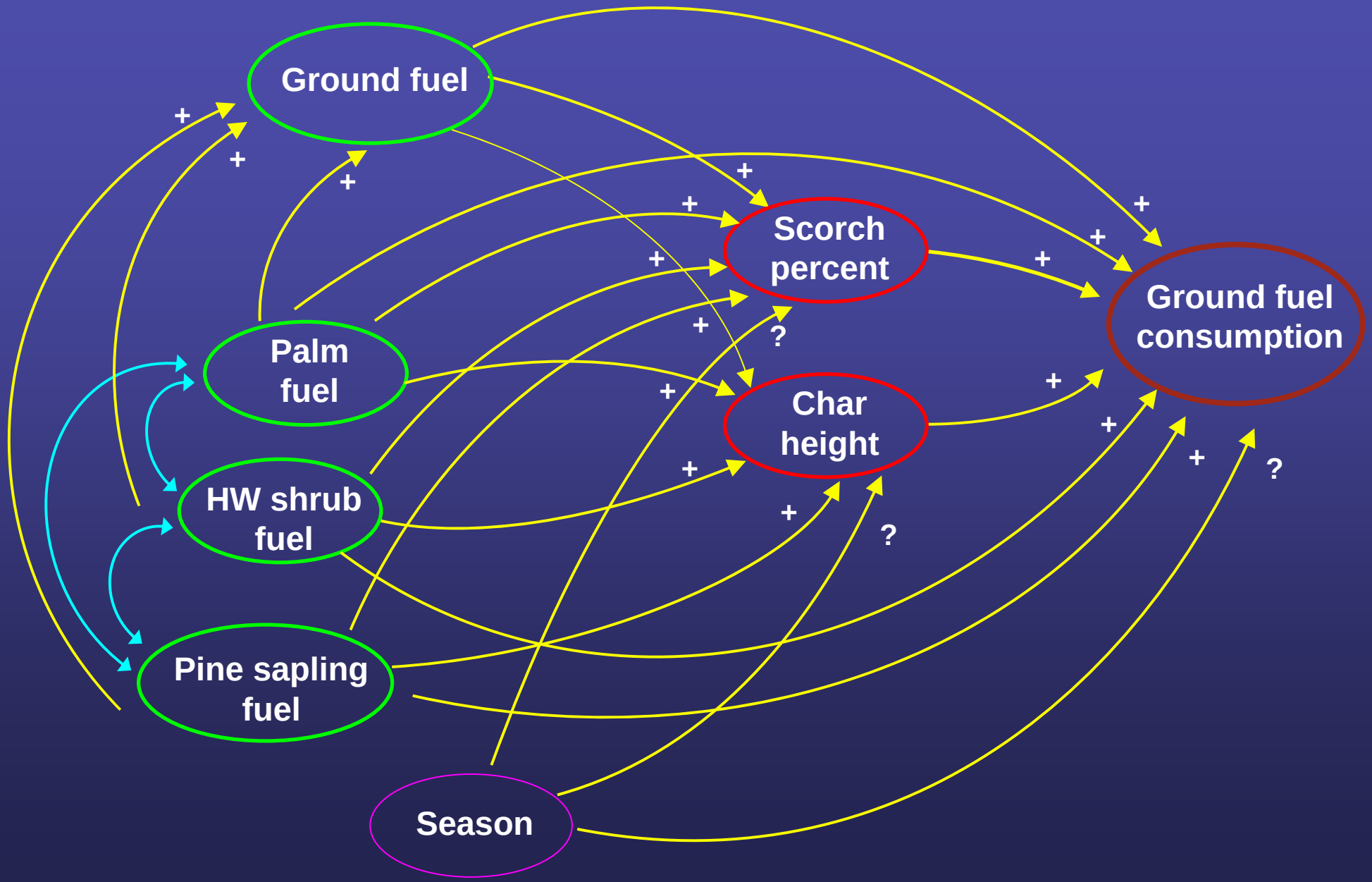
Ground fuel consumption



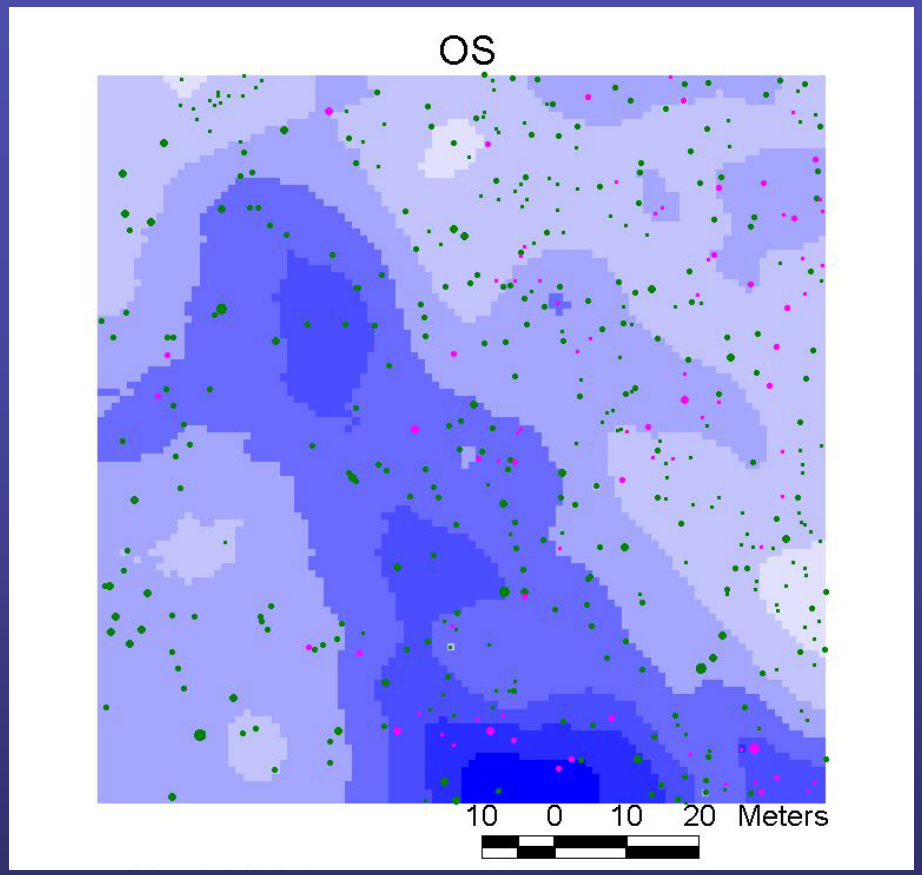
Fuel types & Char height

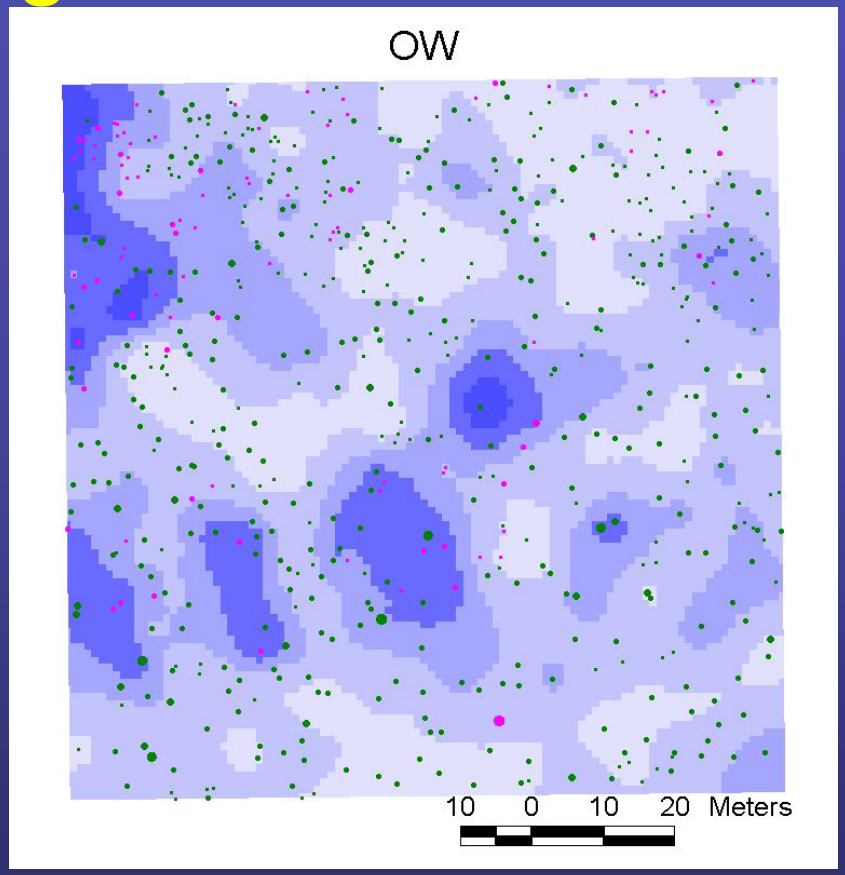


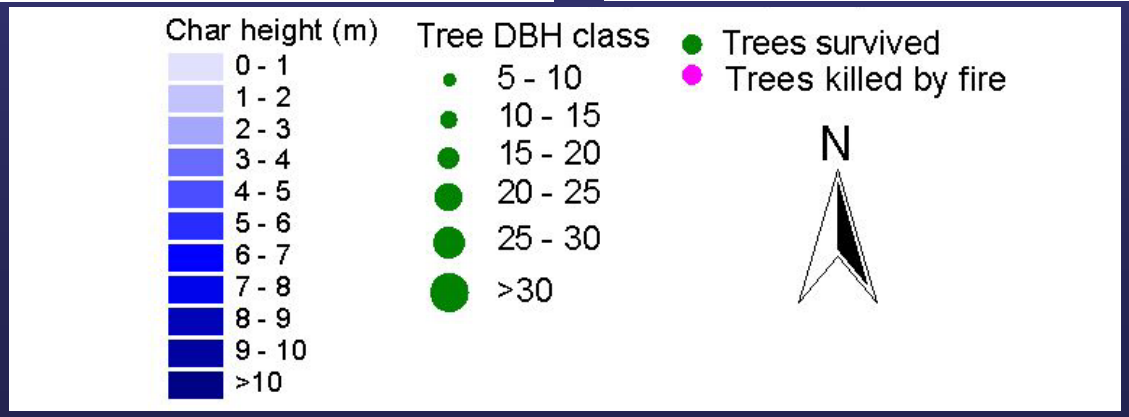
Conceptual causal relationships in the path analysis



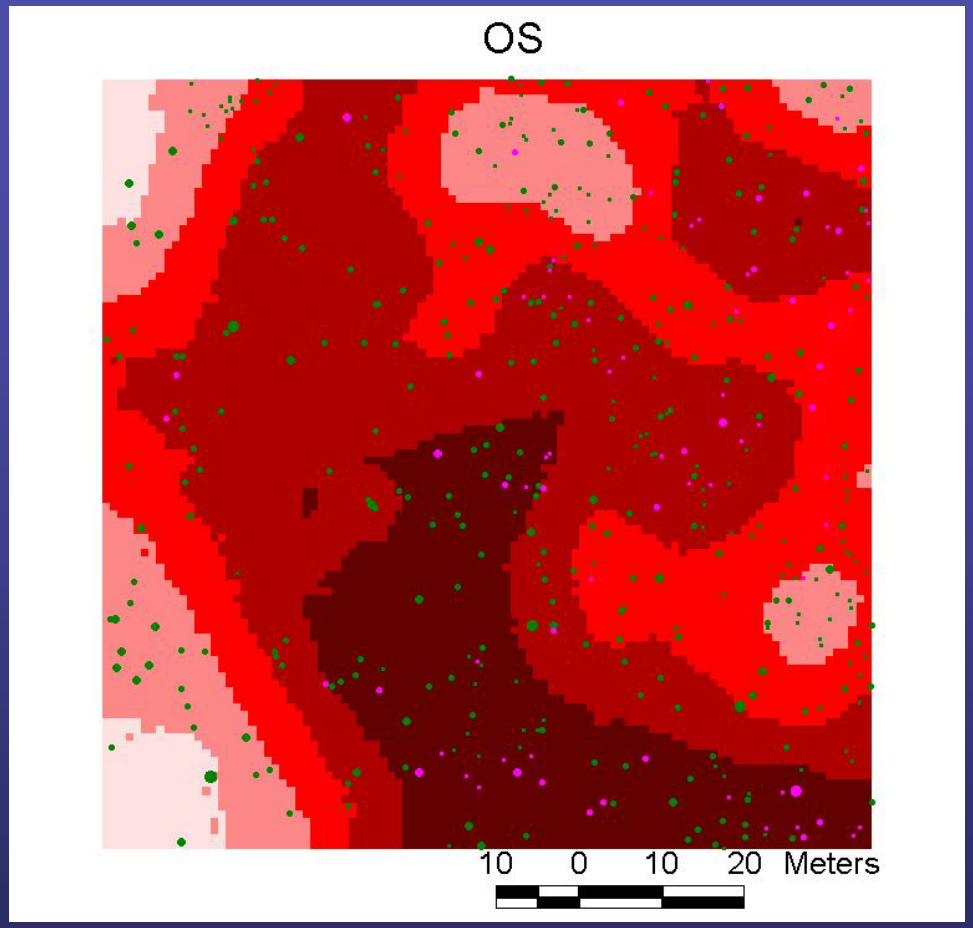
Char height (Block – 'Orchid')

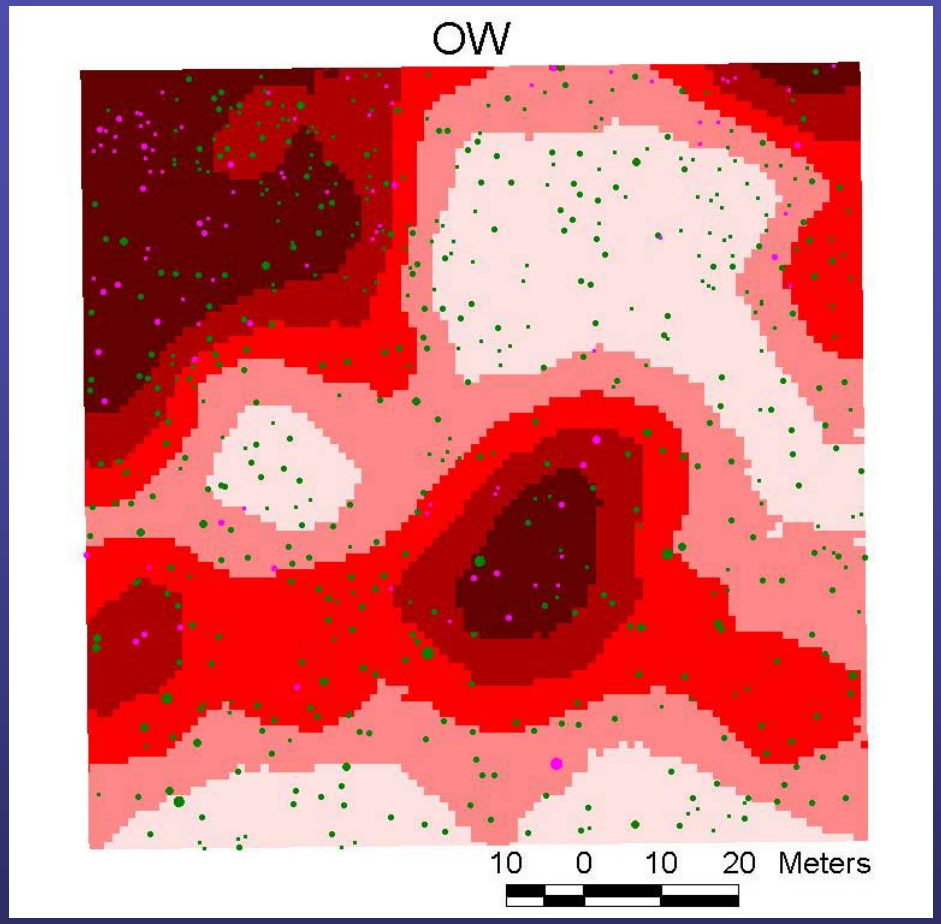






Scorch % (Block – 'Orchid')





Scorch %
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100

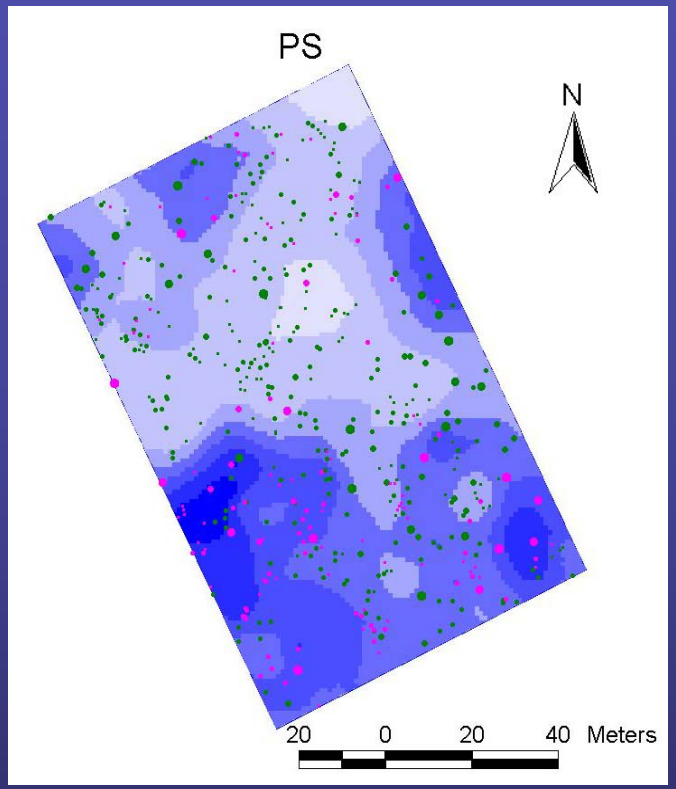
Tree DBH class
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- >30

- Trees survived
- Trees killed by fire

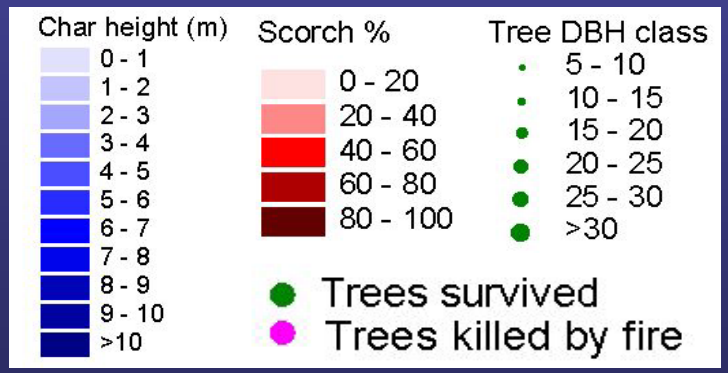
N

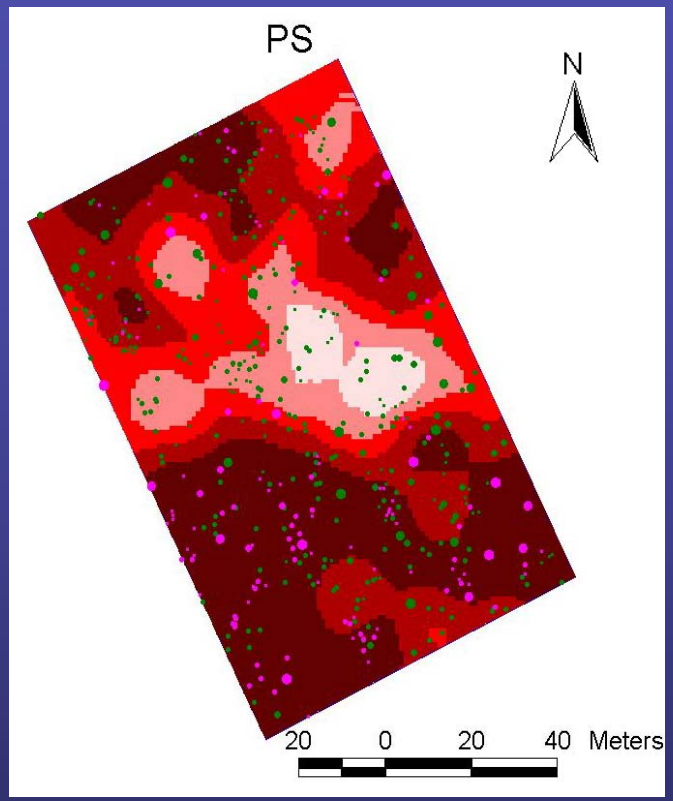
Char height

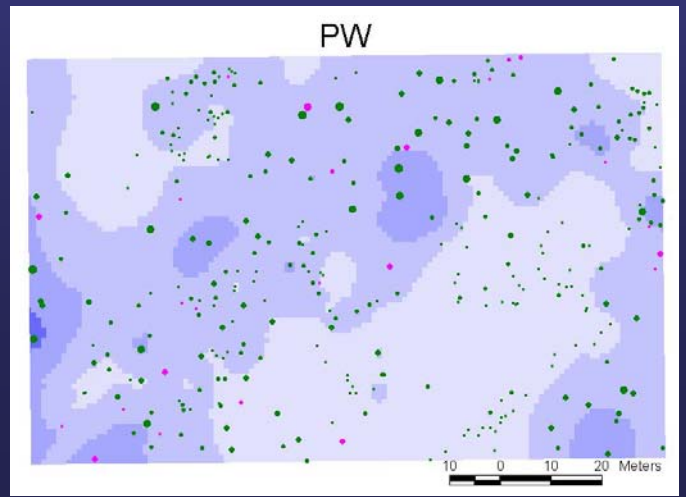
Scorch %

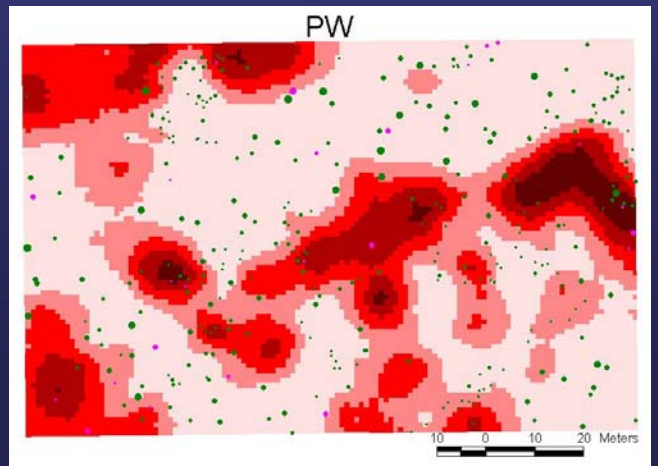


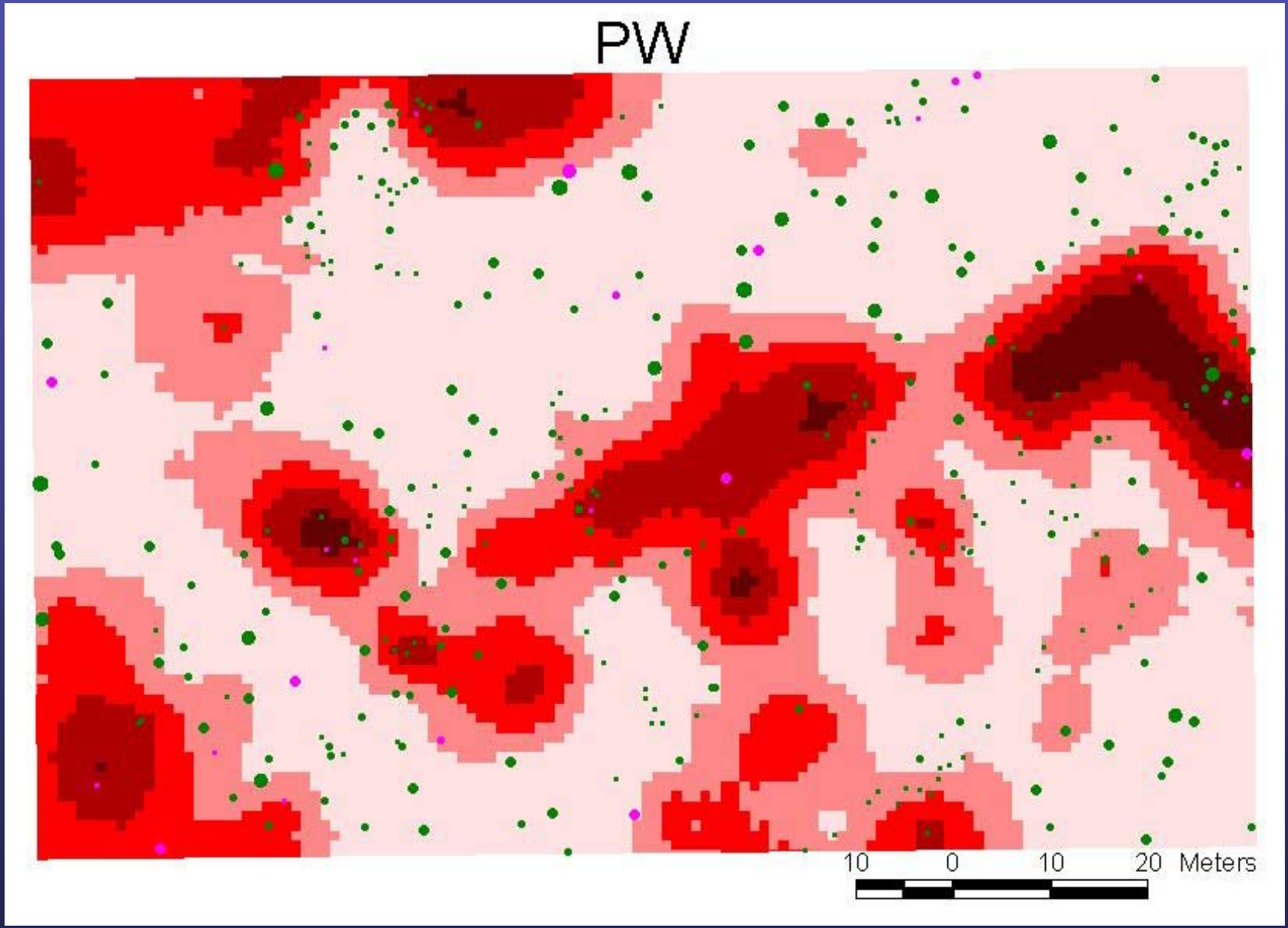
Block – Poisonwood 'Shrubby'

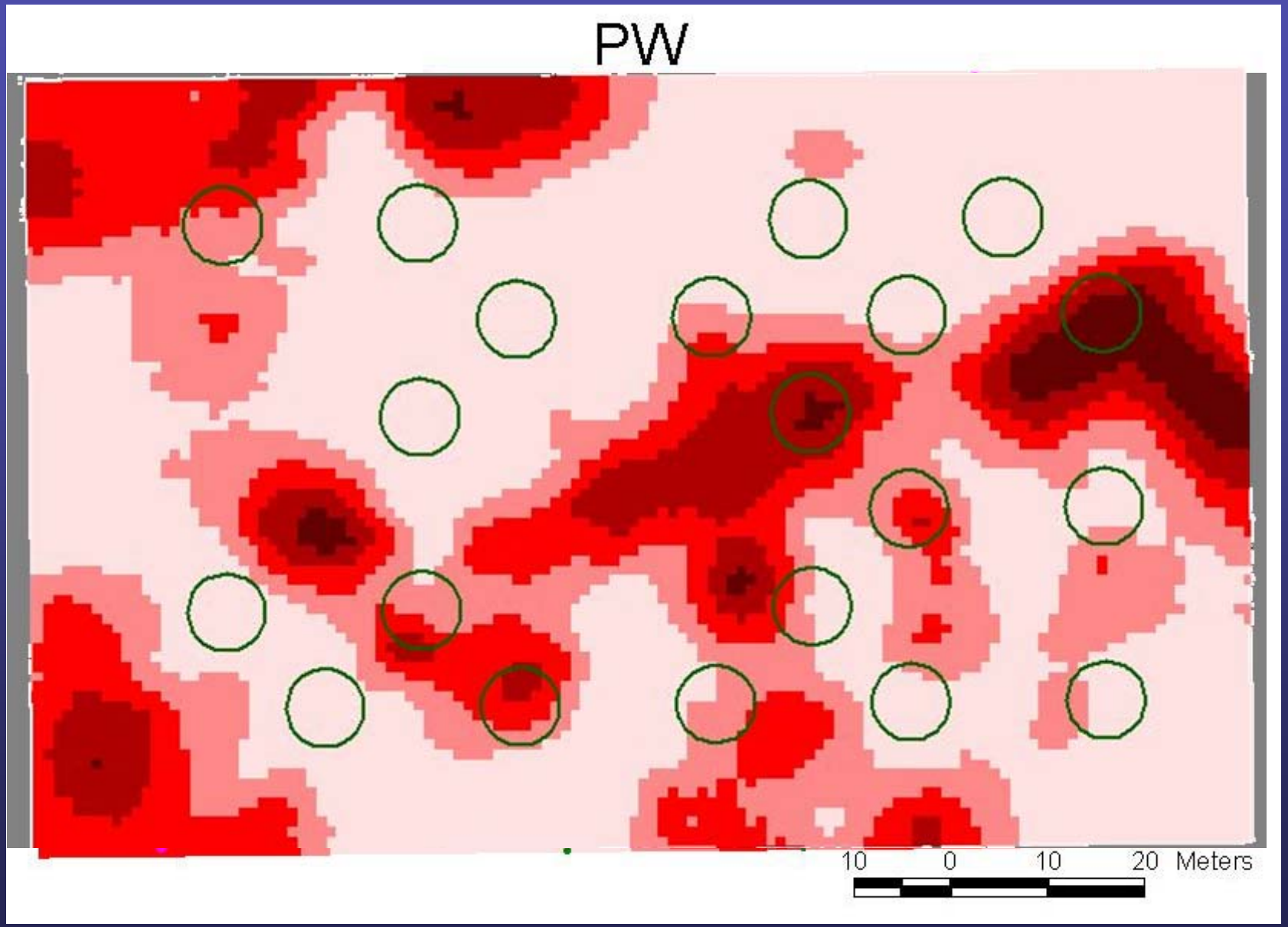


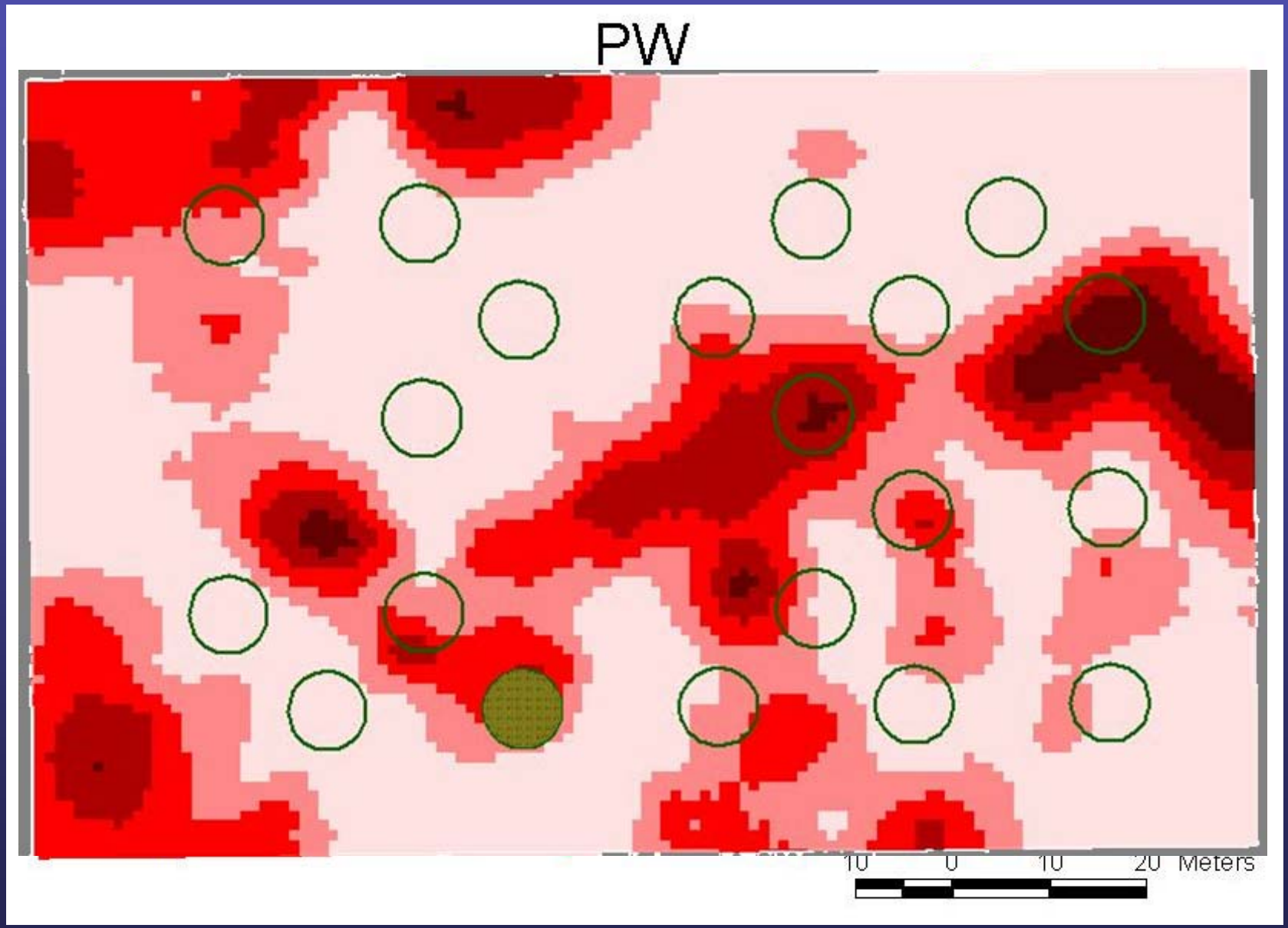


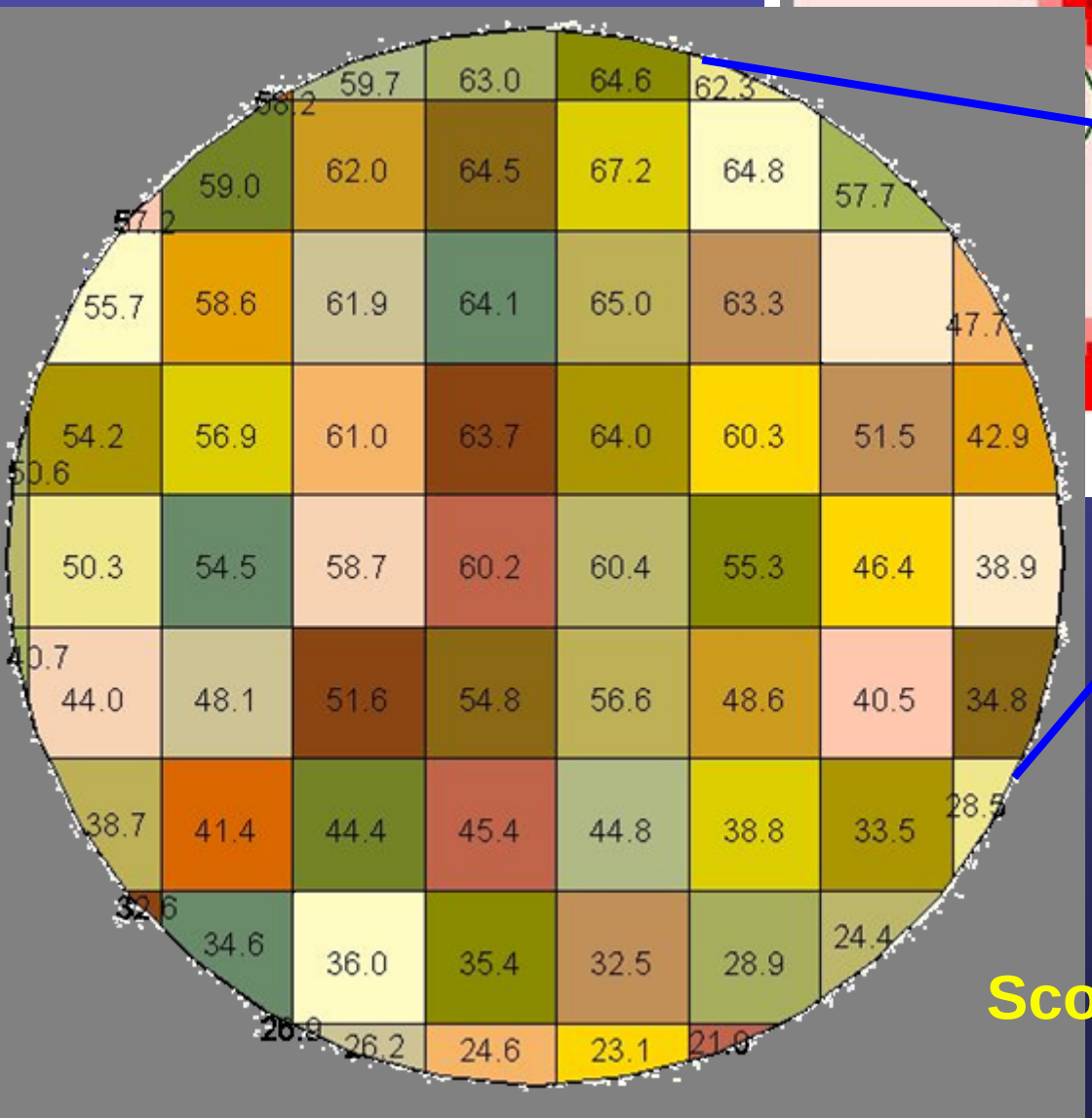


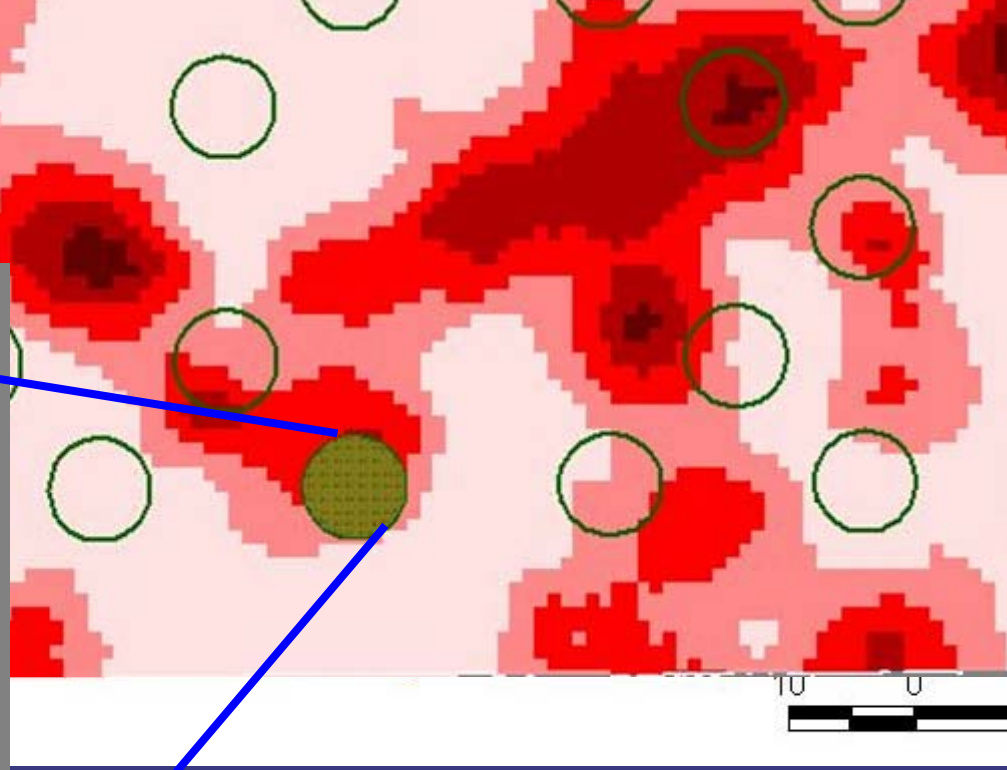



PW
10
0
10
20
Meters


PW
10
0
10
20
Meters


PW
10
0
10
20
Meters

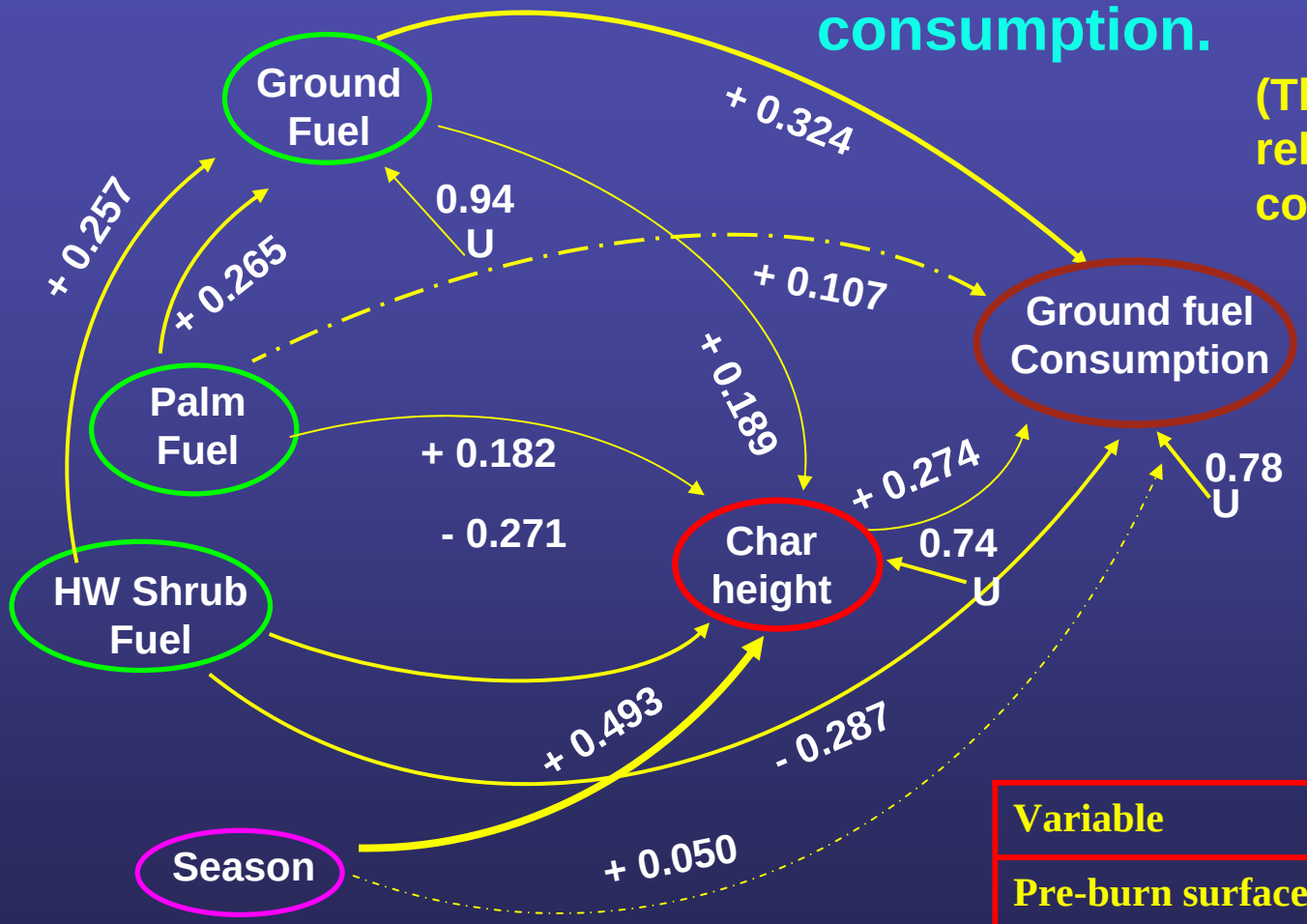

59.7
63.0
64.6
62.3
58.2
59.0
62.0
64.5
67.2
64.8
57.7
57.2
55.7
58.6
61.9
64.1
65.0
63.3
47.7
54.2
56.9
61.0
63.7
64.0
60.3
51.5
42.9
50.6
50.3
54.5
58.7
60.2
60.4
55.3
46.4
38.9
40.7
44.0
48.1
51.6
54.8
56.6
48.6
40.5
34.8
38.7
41.4
44.4
45.4
44.8
38.8
33.5
28.5
32.6
34.6
36.0
35.4
32.5
28.9
24.4
26.2
24.6
23.1


10
0

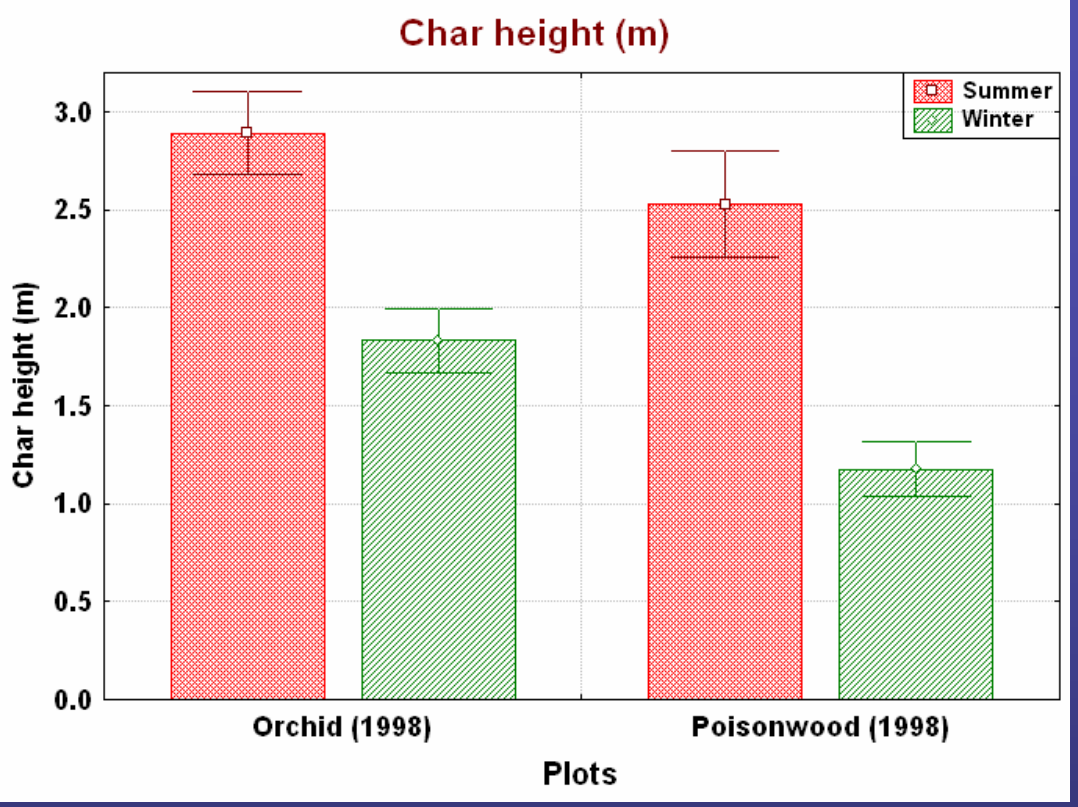
Scorch %

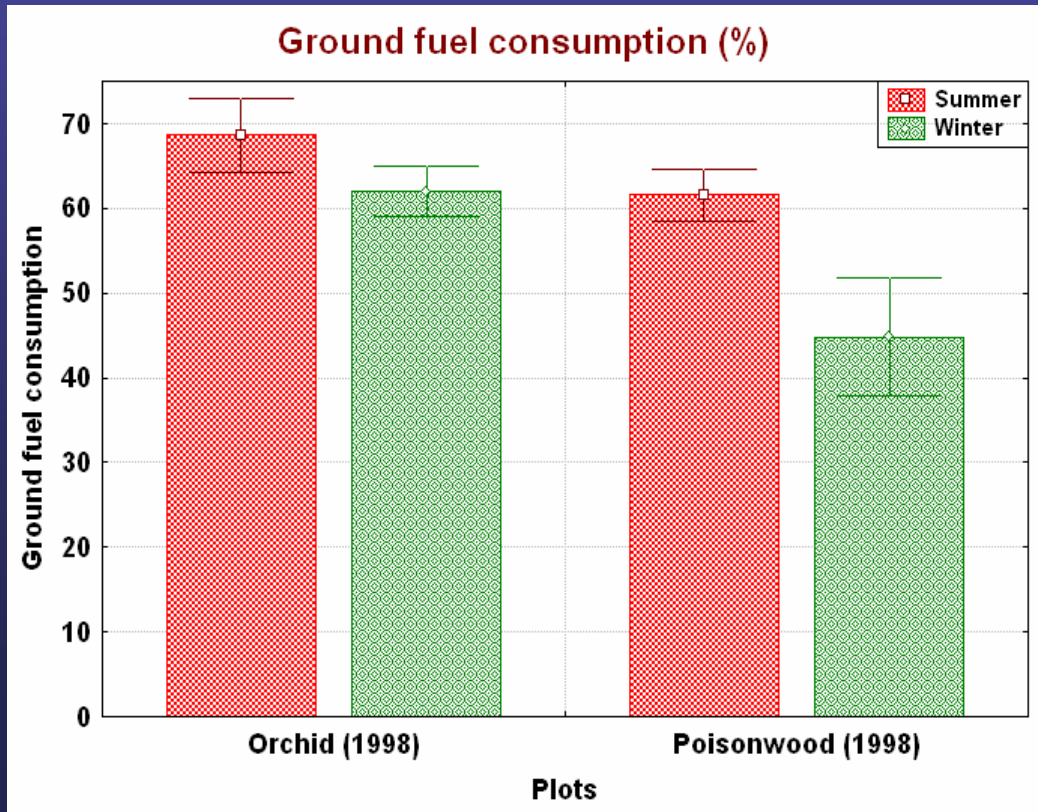
Path diagram showing the relationships among fuel types, fire intensity and fuel consumption.

(The thickness of lines indicates relative strength of significant correlations.)

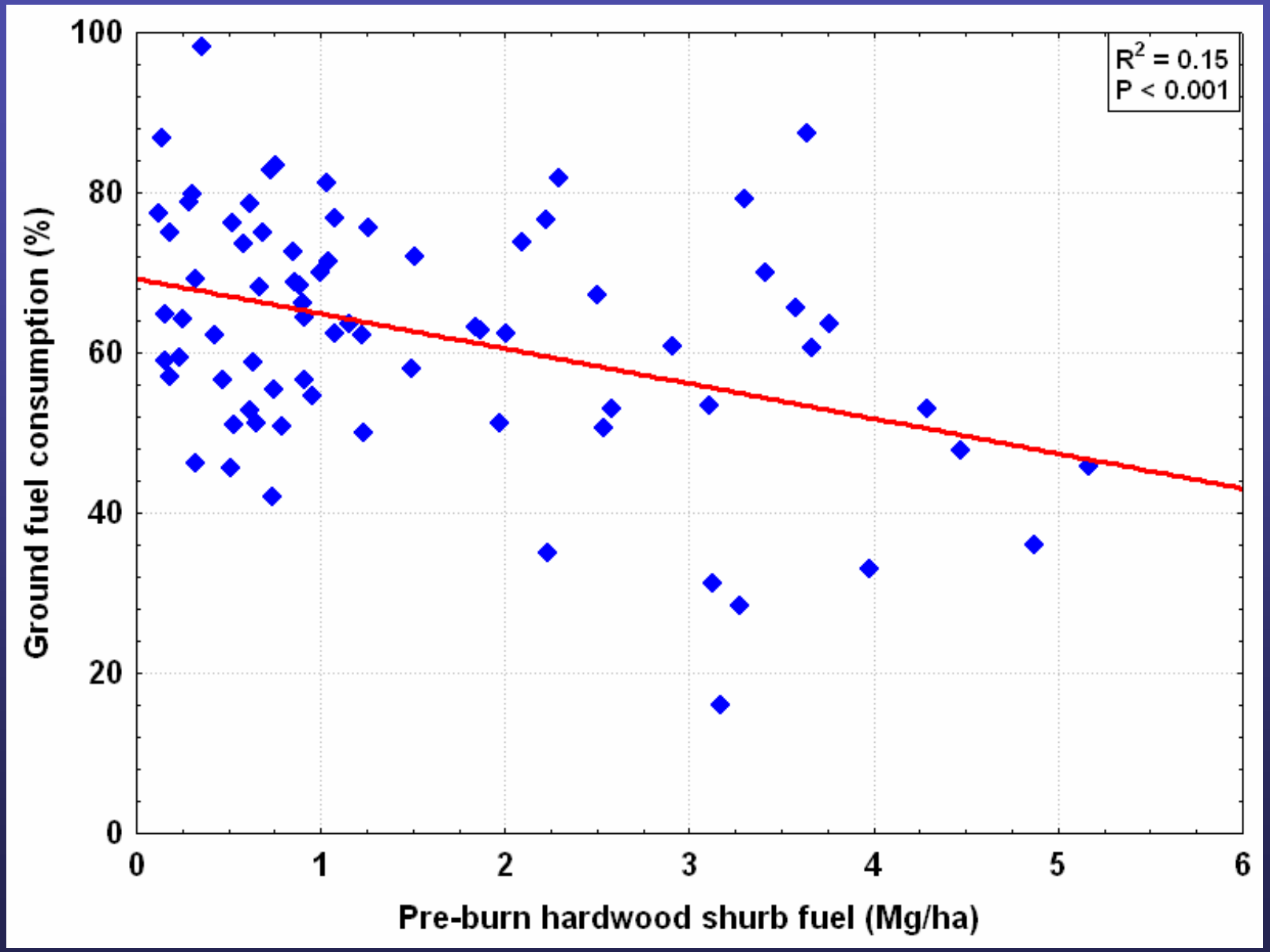


Variable	Direct	Indirect	Total
Pre-burn surface fuel	0.32	0.05	0.38
Palm fuel	0.11	0.15	0.26
Hardwood shrub fuel	-0.29	0.02	-0.27
Char height	0.27	Not modeled	0.27
Season	0.05	0.14	0.19

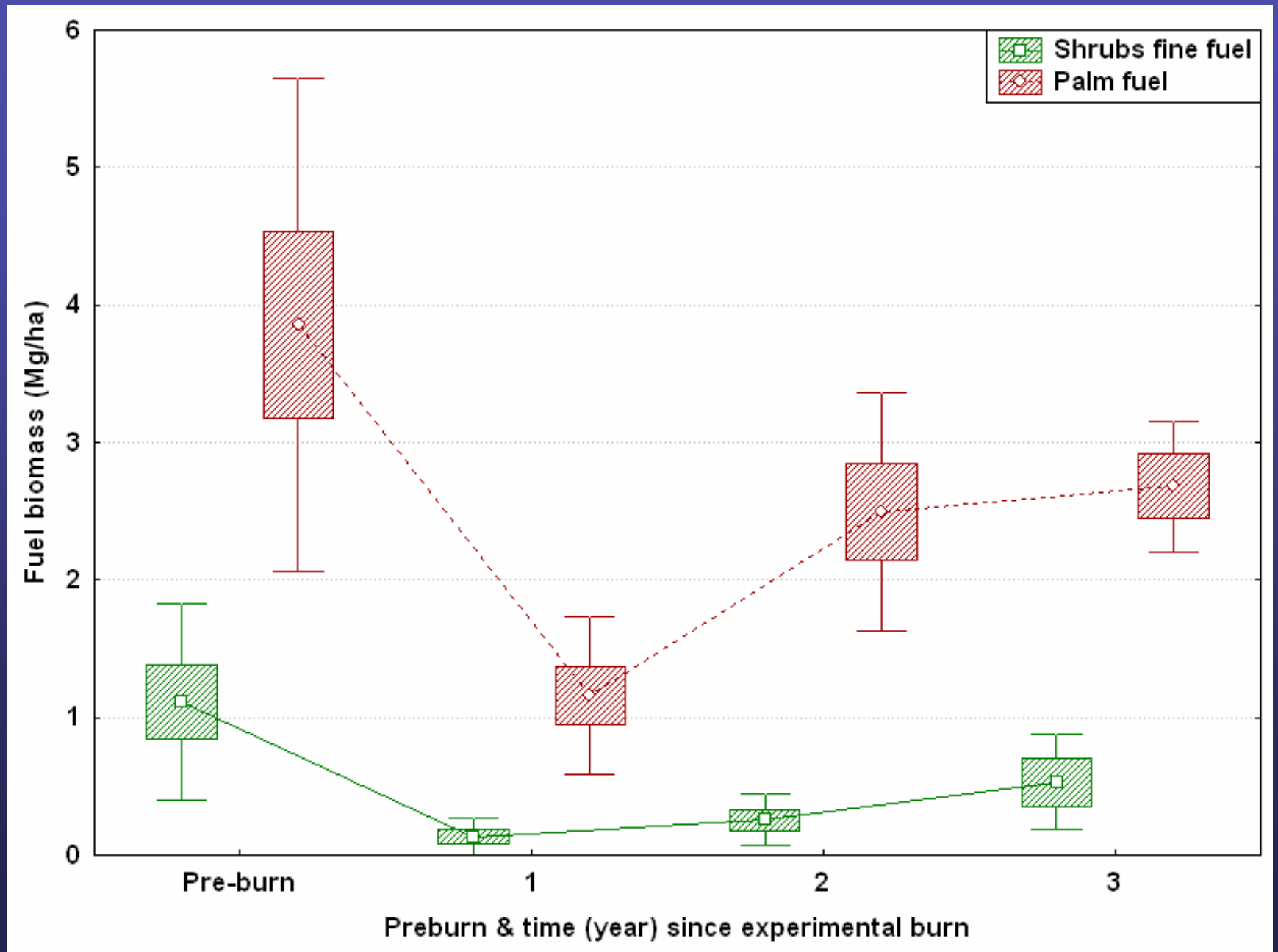

Char height (m)
Summer
Winter
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Char height (m)
Orchid (1998)
Poisonwood (1998)
Plots


Ground fuel consumption (%)
Summer
Winter
70
60
50
40
30
20
10
0
Ground fuel consumption
Orchid (1998)
Poisonwood (1998)
Plots

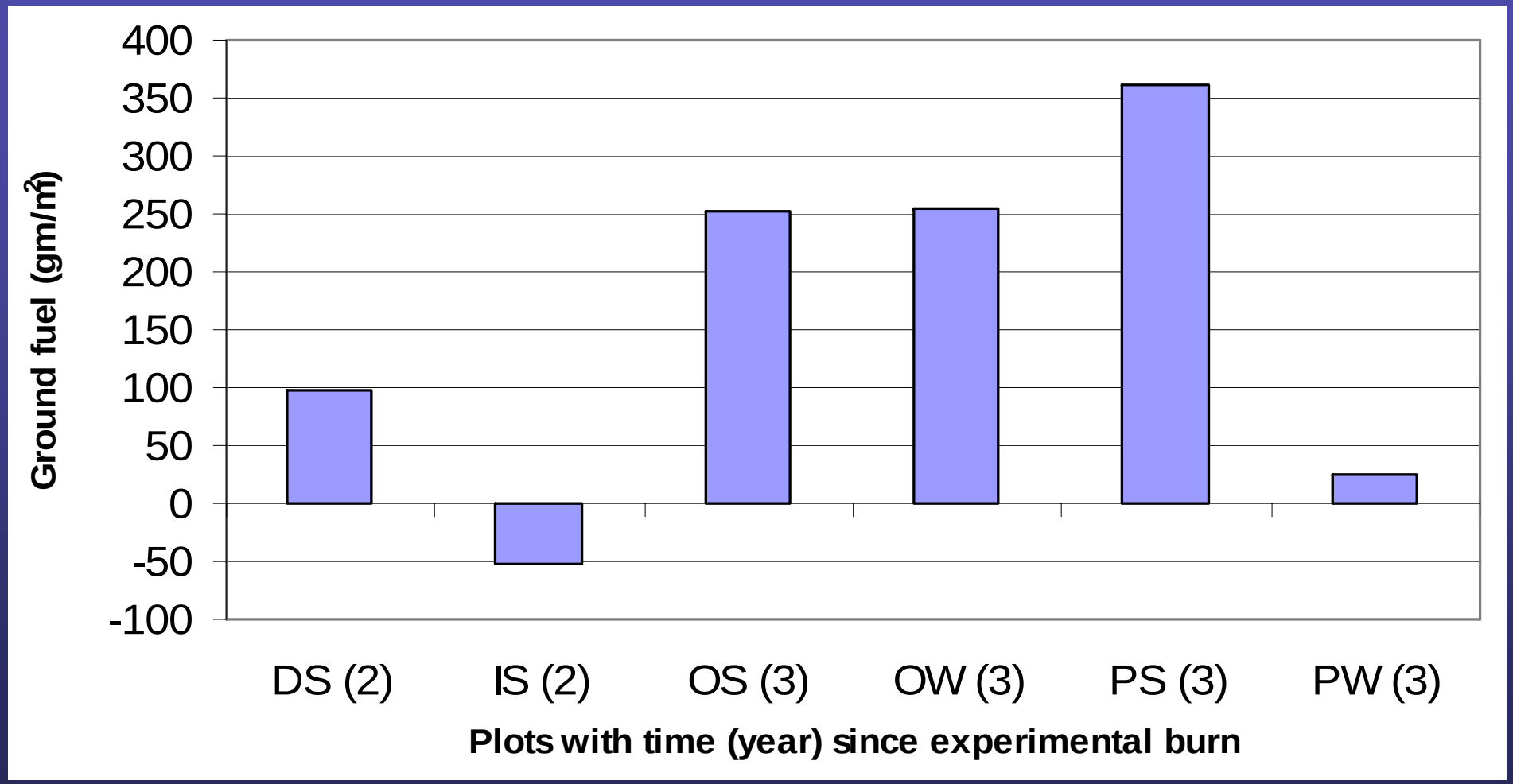
HW shrub fuel vs Ground fuel consumption

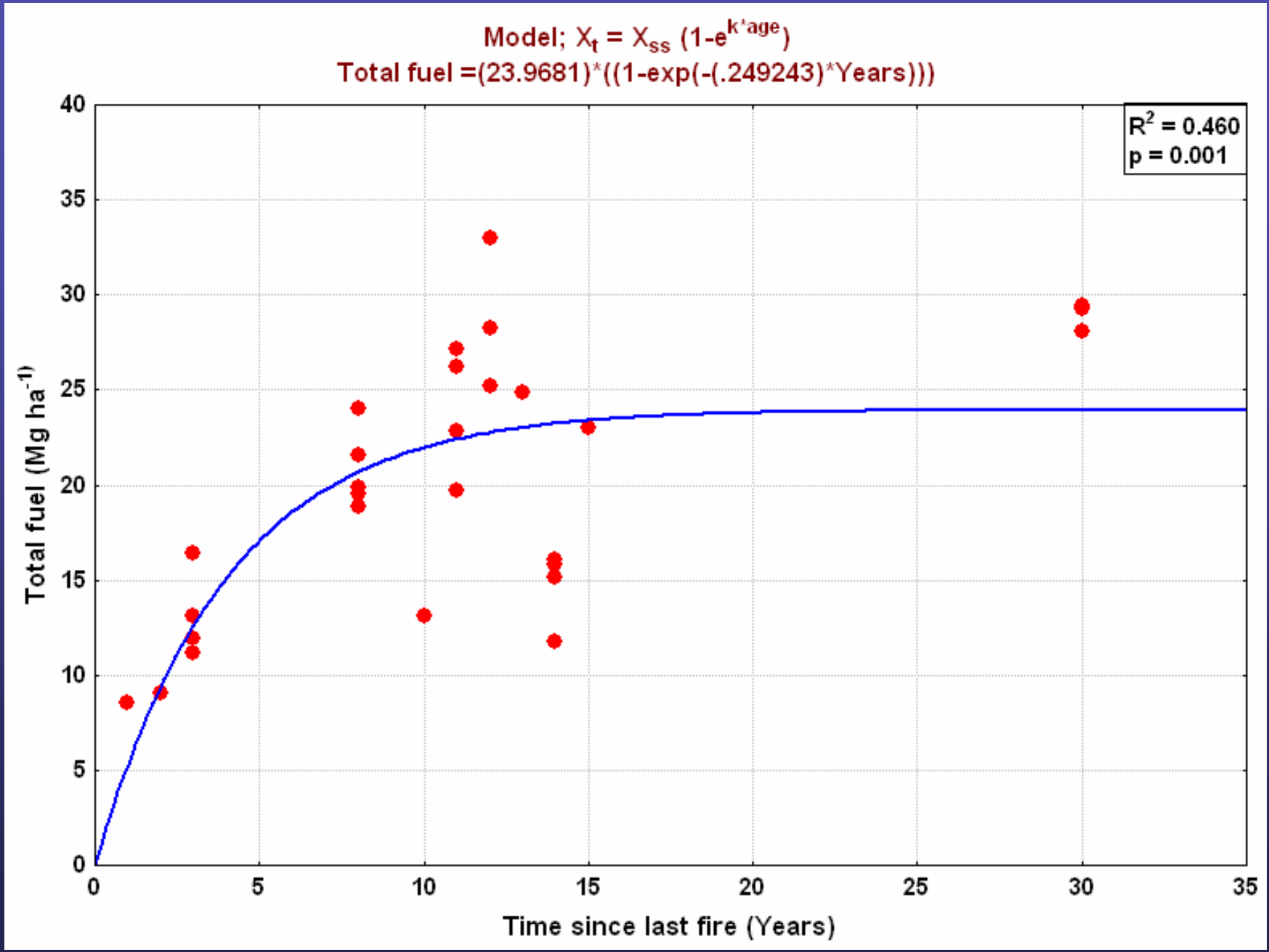


HW shrub & Palm fuels



Ground fuel accumulation after fire




Model; $X_t = X_{ss} (1-e^{k*age})$
Total fuel =(23.9681)*((1-exp(-(.249243)*Years)))
R^2 = 0.460
p = 0.001
Total fuel (Mg ha^{-1})
Time since last fire (Years)
0
5
10
15
20
25
30
35
40

Conclusions

- Total biomass in the Florida Keys pine forests was relatively low.
- Fire intensity increased with surface fuel loads, but was negatively related to the quantity of hardwood shrub fuels. probably because these fuels are associated with a moist microenvironment within hardwood patches, and therefore tend to resist fire.
- Winter fires were milder than summer fires, however effects of season on ground fuel consumption varied among sites.
- Post fire fuel accumulation rate also varied among fuel types and sites.
- Total fuel reached asymtptote at 23-28 t/ha after 8-14 years of fire.

Acknowledgements

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