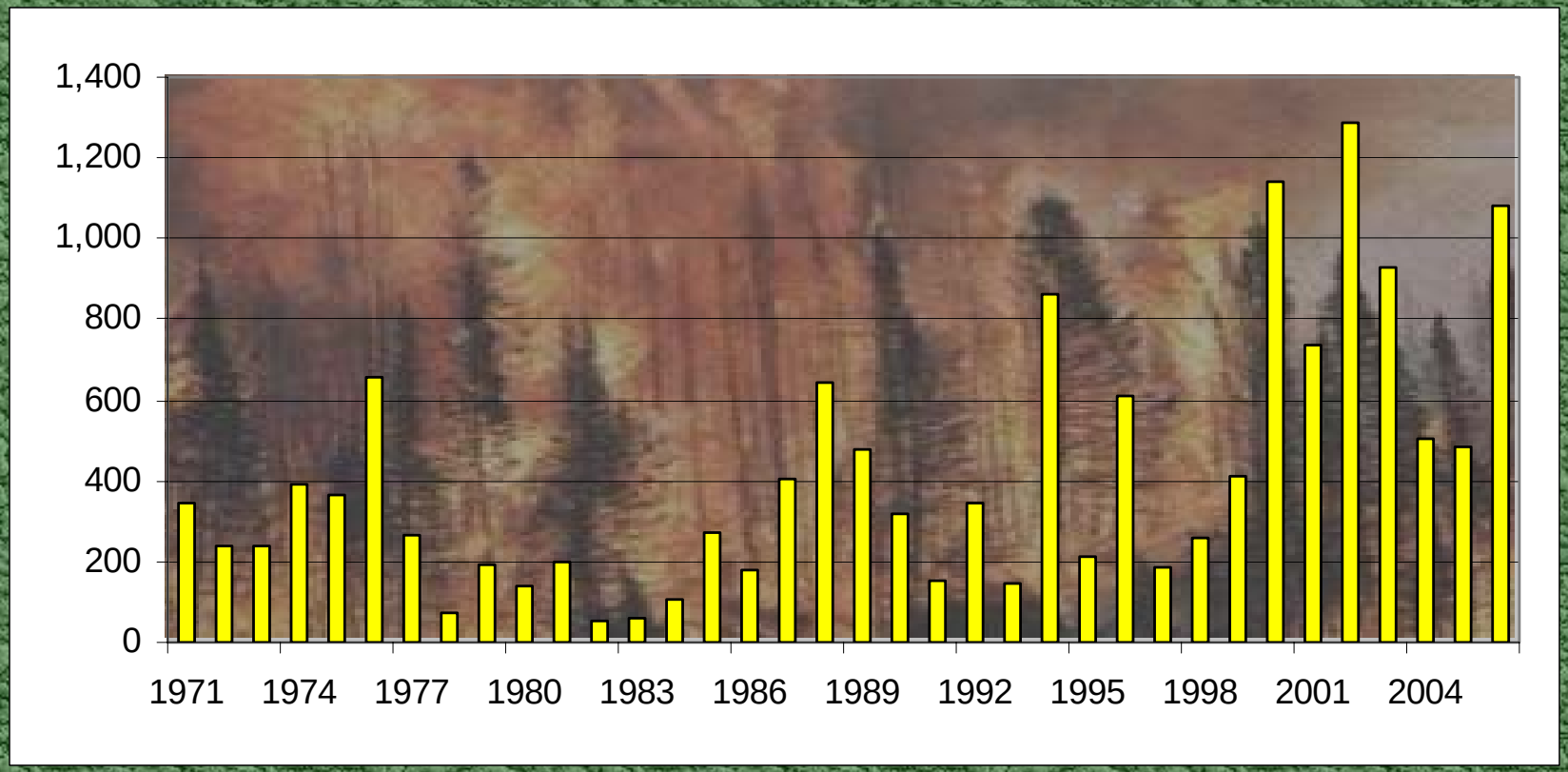
spatial factors influencing large wildland fire expenditures

JINGJING LIANG

forestry sciences lab
rocky mountain research station
u.s. department of agriculture

soaring fire suppression expenditures



Forest Service annual expenditures in 2006 million $

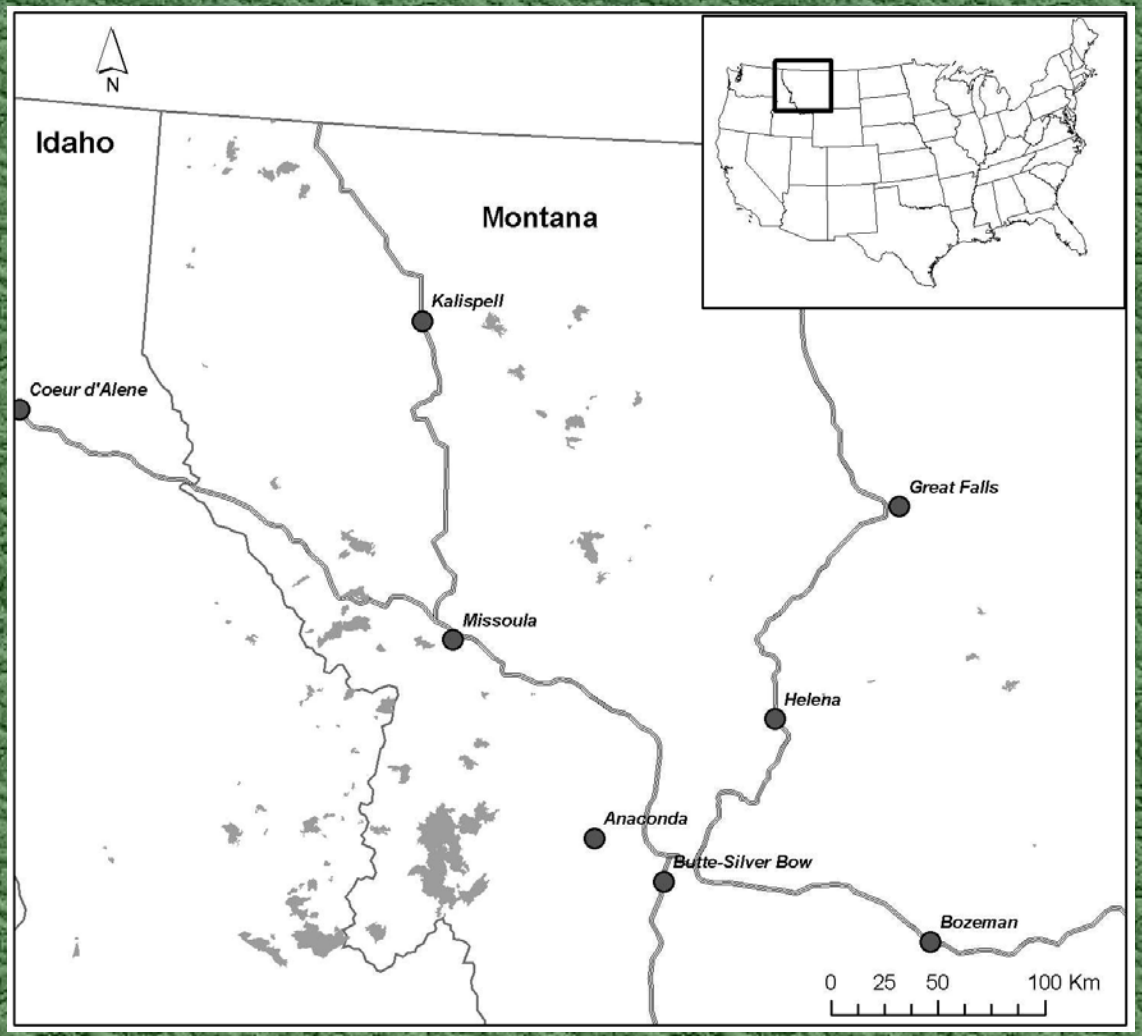
findings from previous studies

- fire size increases suppression expenditures
  (Gonzalez-Caban 1983; Steele and Stier 1998; Donovan *et al.* 2004; Gebert *et al.* 2007)
- terrain conditions affect suppression expenditures
  (Donovan *et al.* 2004)
- home values affect suppression expenditures
  (Gebert *et al.* 2007)

objectives

- test previous findings with spatial explicit fire records
- locate factors influencing suppression expenditures from:
  - fire size and shape
  - properties values threatened
  - geographic settings
  - forest and fuel conditions
- construct a model to predict suppression expenditures

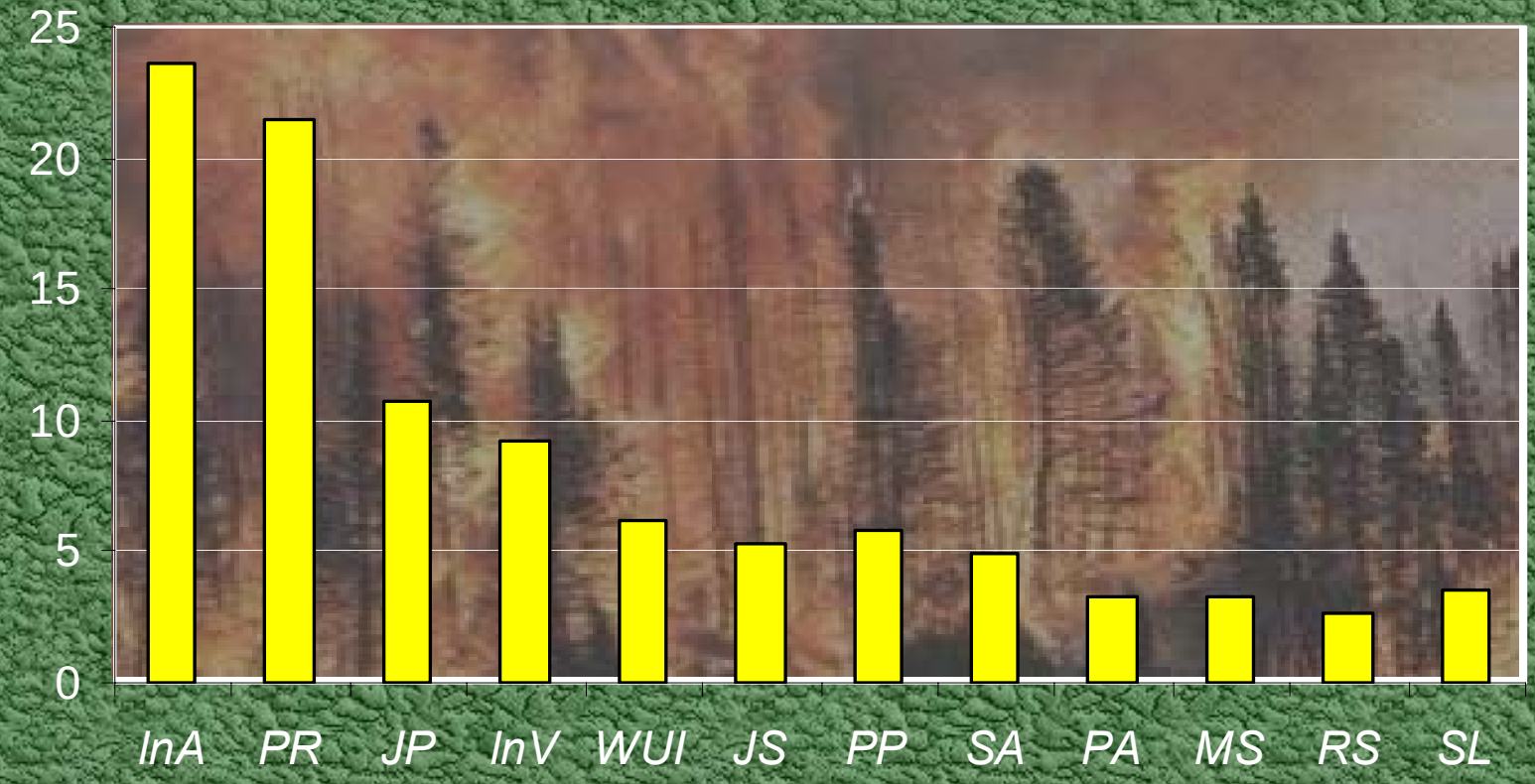
data



- 100 wildfires
- suppressed by the Forest Service
- greater than 300 acres in size

Variable	Description	Unit	Mean	Std (n=100)
lnC	Suppression expenditure in 2005 dollars	*ln*($)	13.00	(2.38)
Fire size and shape				
lnA	Total area within fire perimeter	*ln*(ha)	6.83	(1.37)
PR	Perimeter to area ratio	$10^{-3}m^{-1}$	2.35	(1.37)
Private properties				
JP	Percentage of private land within burned area	%	10.07	(14.17)
lnV	Total structure value (2005$) within an eight-kilometer-buffer surrounding the fire perimeter	*ln*($)	11.51	(6.28)
WUI	Percentage of the wildland-urban interface area within an eight-kilometer-buffer surrounding the fire perimeter, with positive housing density	%	5.84	(8.21)
Public land attributes				
JS	Percentage of state land within burned area	%	0.94	(2.11)
PP	Percentage of public priority areas within burned area	%	0.23	(0.37)
Forest and fuel conditions				
SA	Surface-area-to-volume	$10^{3}m^{-1}$	4.84	(0.37)
PA	Packing ratio		1.53	(0.40)
MS	Moisture content	%	22.97	(1.46)
RS	Rate of spread	$m \cdot h^{-1}$	241.00	(73.13)
FL	Flame length	m	1.28	(0.15)
FF	Fine fuel load	$ton \cdot ha^{-1}$	7.99	(2.77)
Geographic settings				
SL	The percentage of burned area that is less than 35 percent slope	%	52.43	(25.29)
AS	The percentage of burned area with a northern aspect (±45° from north)	%	22.75	(14.64)
EL	Average elevation of burn area	$10^{3}m$	1.69	(3.39)
Fire central point				
x	Easting of UTM coordinates	$10^{6}m$	0.56	(0.15)
y	Northing of UTM coordinates	$10^{6}m$	5.19	(0.11)

the most prominent factors



Contribution of explanatory variables to the goodness-of-fit of suppression expenditures

does size matter?

$y = 6.10^{**} + 1.01^{**} \cdot lnA$

F	*P*	R^2	DW
50.03	0.00	0.33	1.16

so size matters, how about shape?

$$y = 9.53^{**} + 0.66^{*} \cdot \ln A - 0.43 \cdot PR$$

F	*P*	R^2	DW
26.88	0.00	0.34	1.14

does private properties matter?

$$y = 5.46^{**} + 0.95^{**} \cdot lnA + 0.06^{**} \cdot JP + 0.04 \cdot lnV$$

F	*P*	R^2	DW
32.14	0.00	0.49	1.41

any other factors?

$$y=\delta_0+\delta_1 lnA+\delta_2 JP+\delta_3 Wui+\delta_4 JS+\delta_5 PP+\delta_6 SA+\delta_7 PA+\delta_8 MS+\delta_9 RS+\delta_{10} FL+\delta_{11} FF+\delta_{12} SL+\delta_{13} AS+\delta_{14} EL+e$$

$$P[H_0: \delta_3=\delta_4=\ldots=\delta_{14}=0 \mid \delta_1, \delta_2]=0.29$$

conclusion: only size and percentage of private land matter.

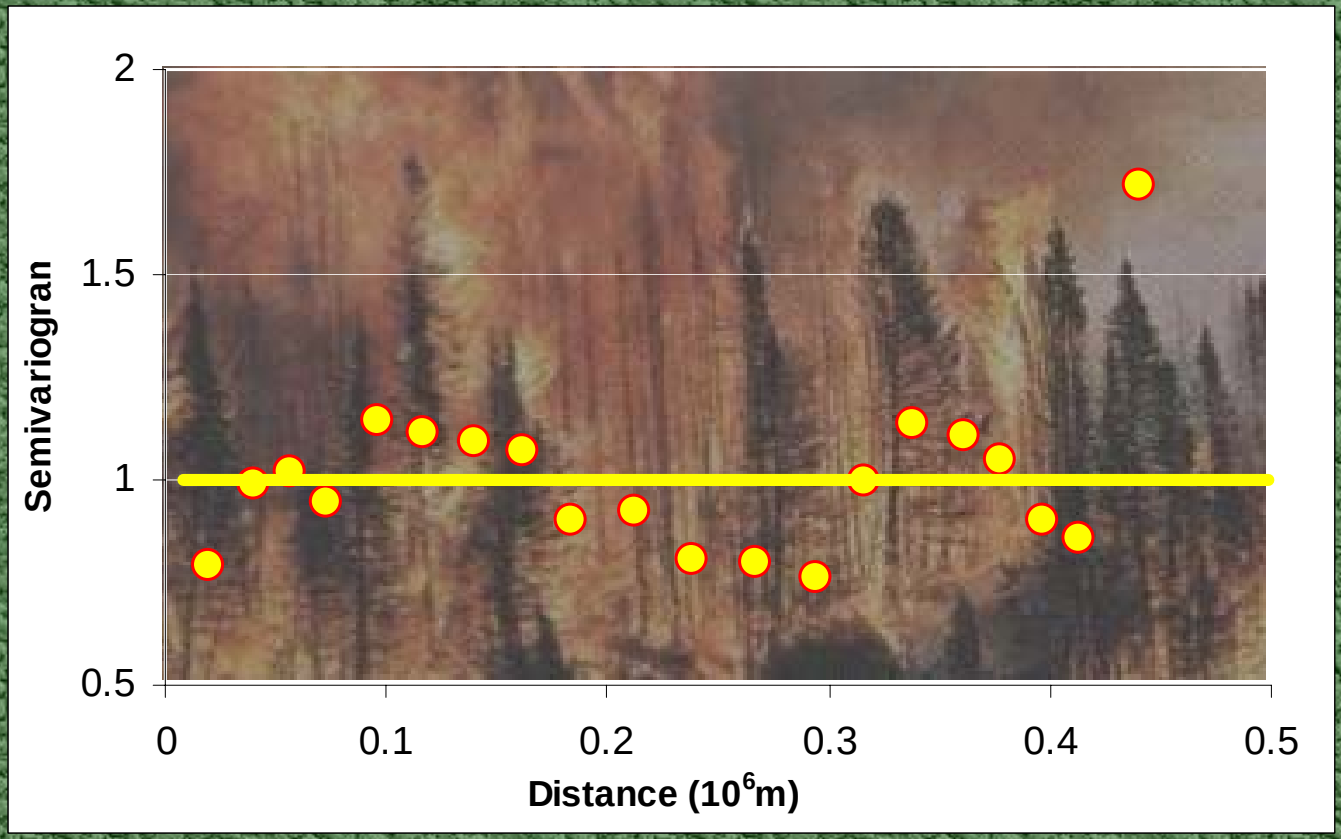
predicting suppression expenditures

$$y = 5.48^{**} + 0.92^{**} \cdot lnA + 0.36^{**} \cdot JP - 0.01^{**} \cdot JP^2 + 0.001^{**} \cdot JP^3$$

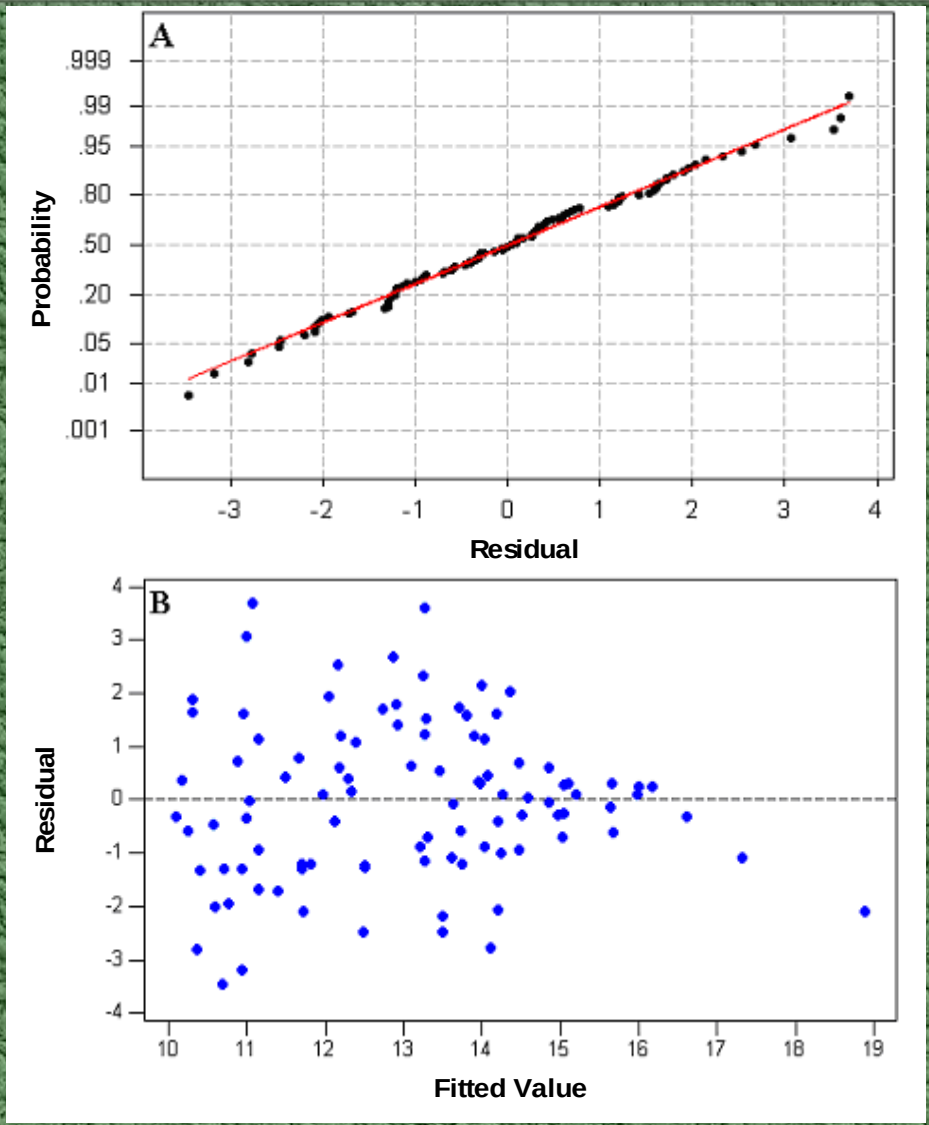
F	*P*	R^2	DW
34.54	0.00	0.58	1.72

residuals: spatial autocorrelation

$$y=\eta_0 + \eta_1 lnA + \eta_2 JP + \eta_3 JP^2 + \eta_4 JP^3 + e(x,y)$$

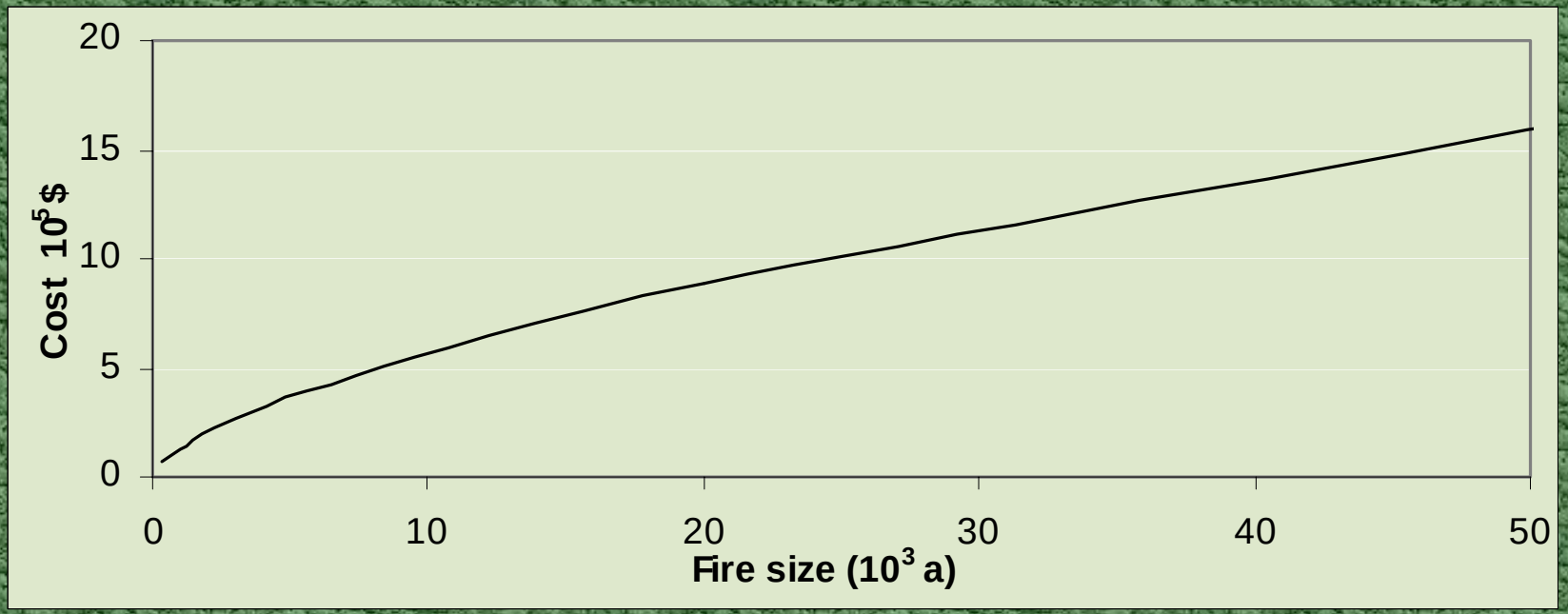


residuals: normality



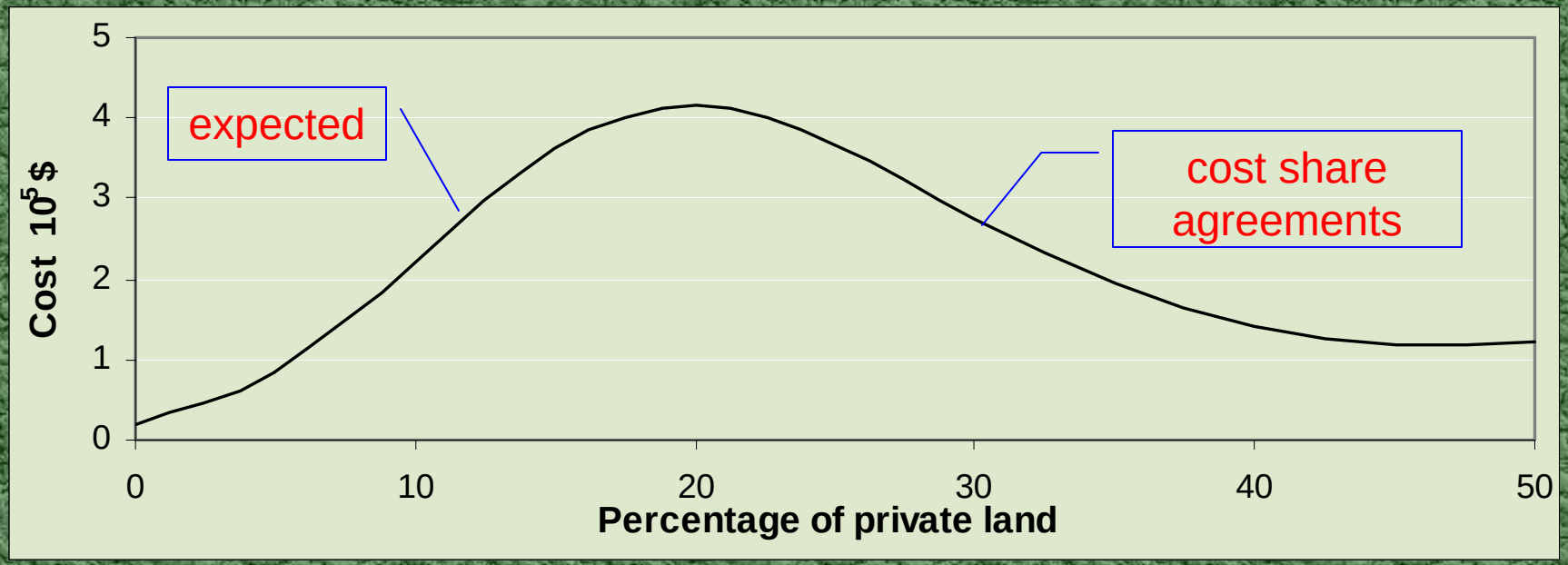
A^2=0.24, *P*=0.76

sensitivity analysis- fire size



$$y = 5.48 + 0.92 \cdot lnA + 0.36 \cdot JP - 0.01 \cdot JP^2 + 0.001 \cdot JP^3$$

sensitivity analysis- private land



$$y = 5.48 + 0.92 \cdot lnA + 0.36 \cdot JP - 0.01 \cdot JP^2 + 0.001 \cdot JP^3$$

discussion

- prioritization of private property protection had significantly increased wildfire suppression costs
- natural resources had not been given equal consideration
- The role and responsibilities of all levels of government and private parties must be thoughtfully considered in fighting wildfires within populated interface areas.

epilogue

- spurious correlation is avoided by carrying rigorous statistical tests.
- spatial factors explained 58% of variation in suppression expenditures.
- managerial factors might help to improve the model.