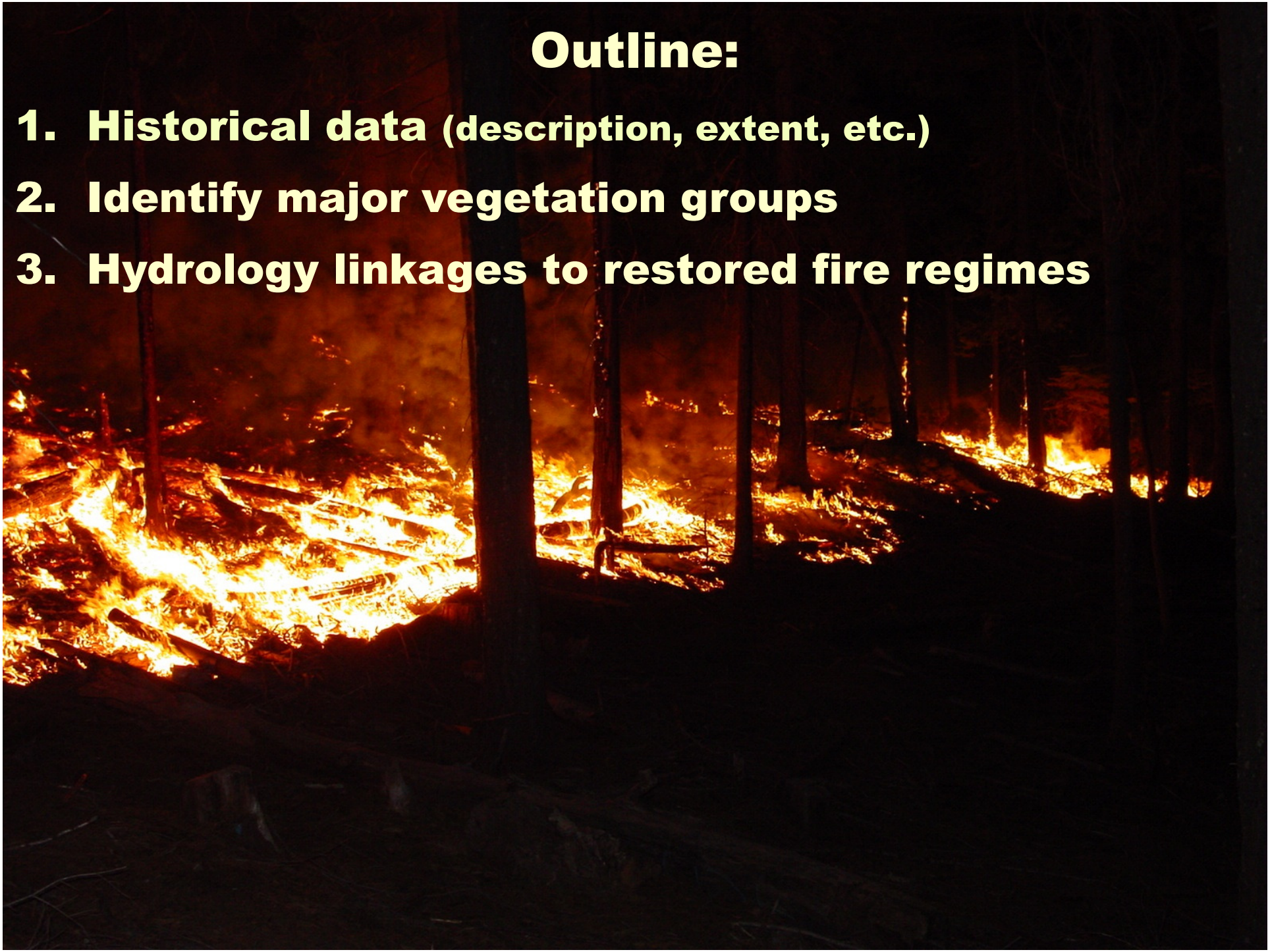
Variability in forest structure across a central Sierra Nevada landscape from 1911 inventory data

Scott Stephens and Brandon Collins – *UC Berkeley and USFS PSW*



Outline:

1. **Historical data (description, extent, etc.)**
2. **Identify major vegetation groups**
3. **Hydrology linkages to restored fire regimes**


The Data

Form 321 a. ✓

UNITED STATES DEPARTMENT OF AGRICULTURE,
FOREST SERVICE.

"Forty" Estimate Sheet.

Slope SW

Tp. 1 S, R. 20 E, MD M. Sec. 19, Forty NE¼ NW 3 Course Due N

Sheet Number 243 Series, Date 7-8, 1911

Examiners { Estimator E H Coulson
Compassman J R Batty

D. B. H.	YP Species				SP Species				WF Species				IC Species				Miscellaneous Green; Dead (All Species)			
Ins.	1	2 Number	3 of logs	4	1	2 Number	3 of logs	4	1	2 Number	3 of logs	4	1	2 Number	3 of logs	4	YP	SP Number	WF of logs	IC
Poles	☒																Seedlings			
12	··			✓									··		✓		15			20
14	··																Saplings			
16		·	✓														10			8
18		·											··				Dead			
	4	5 Number	6 of logs	7	4	5 Number	6 of logs	7	4	5 Number	6 of logs	7	3	4 Number	5 of logs	6	4	Number	of logs	3
20	·· ✓ ··	✓																		
22		·✓																		
24	·✓	·· ✓											✓							
26		·✓	·· ✓																	·
28			·· ✓	·· ✓													·			
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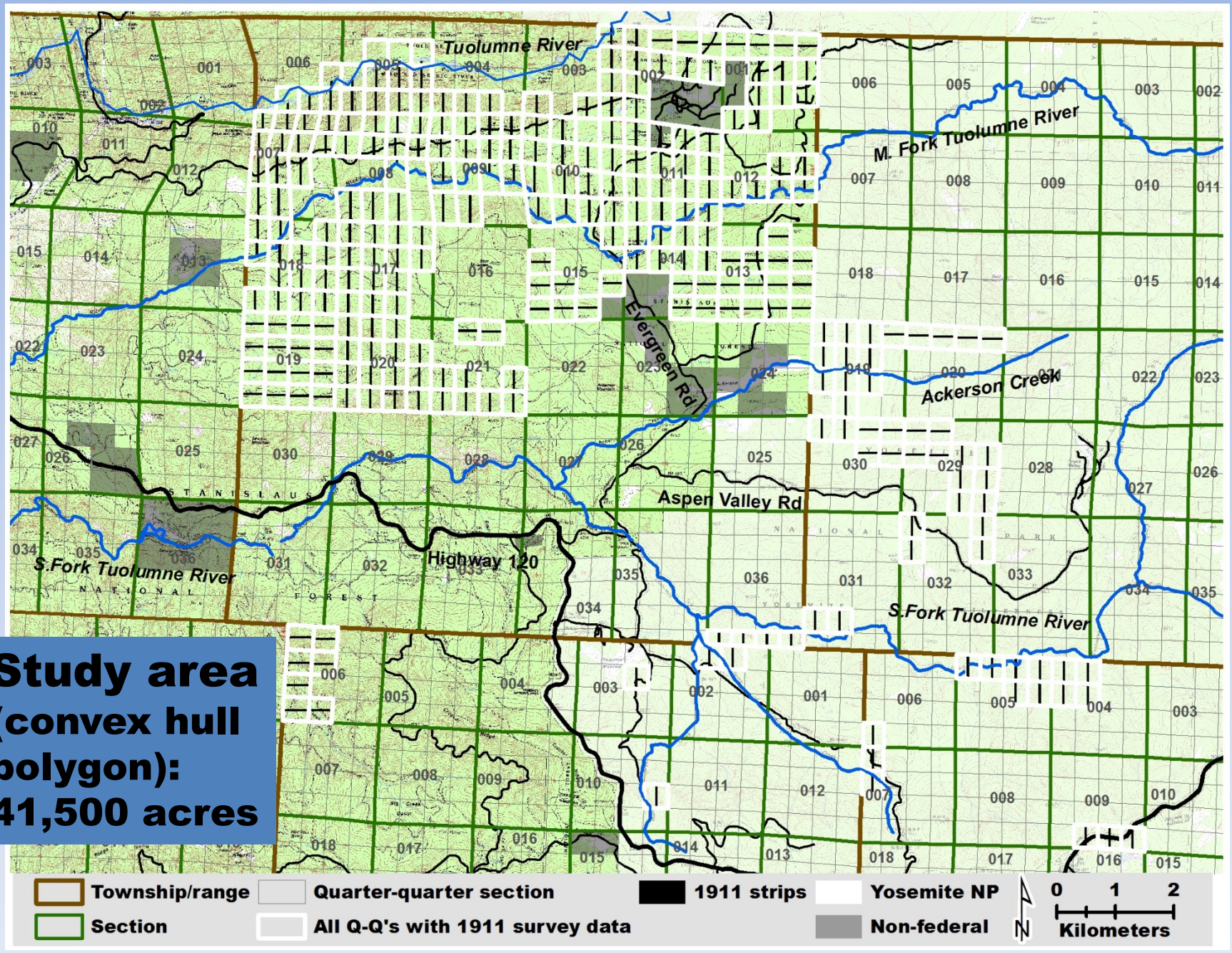
32			·· ✓										·· ✓							
34			·· ✓	·· ✓									·· ✓				·			
36			··	·· ✓									·· ✓	✓						
38				·· ✓										·						
	6	7 Number	8 of logs	9	6	7 Number	8 of logs	9	6	7 Number	8 of logs	9	5	6 Number	7 of logs	8	8	Number	of logs	
40			·· ✓																	
42				·· ✓																
44							·· ✓													
46																				
48																	-			
50	·			·· ✓																
52																				

8—1198

Full extent of 1911 data – Stanislaus NF, YNP



Field plot within Rim Fire

Pre-fire (15-Jul-2013)

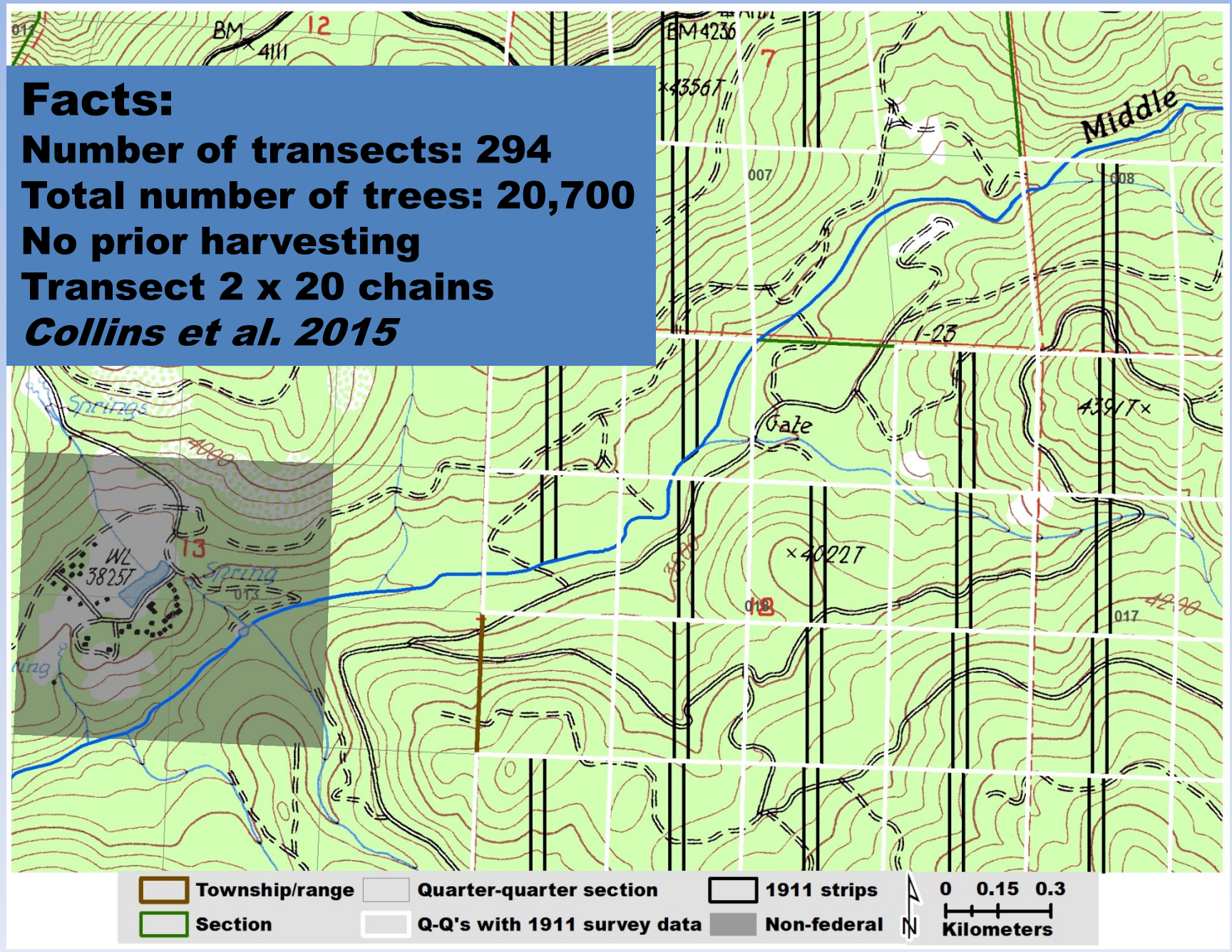
Field plot within Rim Fire

Post-fire (25-Sep-2013)

Current versus historical forest conditions: based on re-measurement of timber surveys initially conducted in 1911

Year	Total basal area ($ft^2\ ac^{-1}$)	Number of trees > 6 inches ($acre^{-1}$)
1911	59	19/acre
2013	248	224/acre

1911 timber survey transects – Stanislaus NF



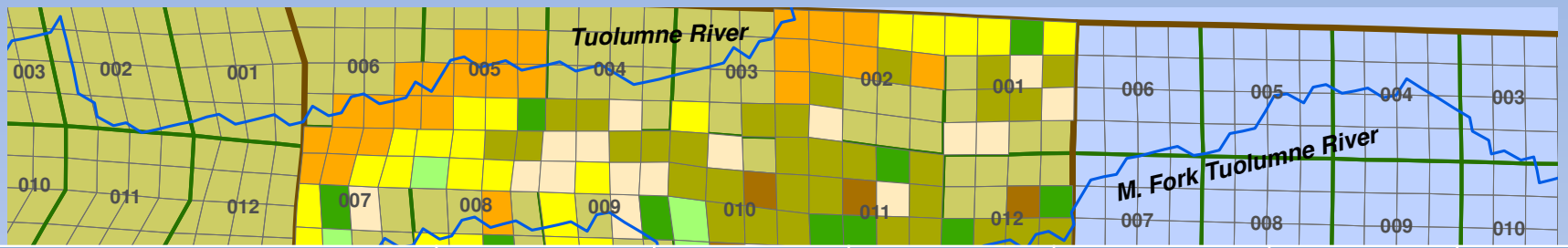
Identify distinct historical vegetation groups

K-means cluster analysis-fire

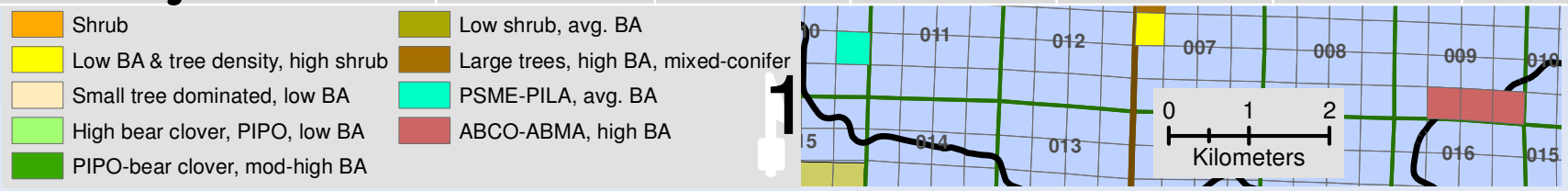
- **Minimize variability within a cluster and maximize variability between clusters**
- **Based on Euclidian distances between transects (n=294)**
- **Input variables:**

  BA by species, tree density by size class, shrub and bear clover cover (*develop classification*)

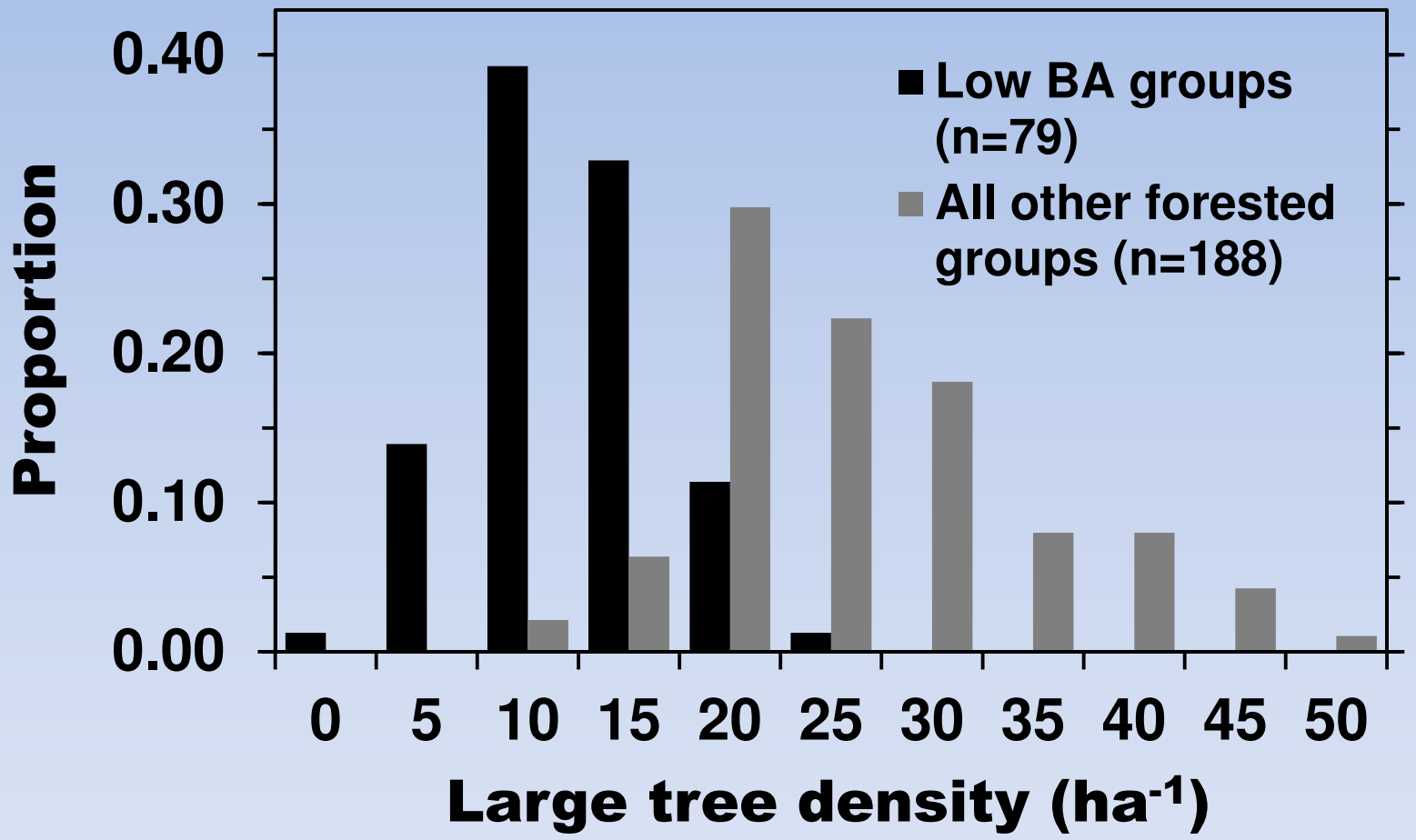
1911 forest type groups – Stan. NF, Yose. NP



Vegetation group	No. (transects)	CHFO (% cover)	Shrub (% cover)	Total BA (m^2 ha^{-1})	Trees > 6" (ha^{-1})	Canopy cov. (%)
Shrub	27	2	84	0	0	0
Low BA, high shrub	48	25	54	8	25	9
Low BA, high small trees	31	32	22	10	49	12
PIPO, low BA, high CHFO	44	80	11	14	38	16
PIPO, high BA, mod CHFO	41	55	21	22	73	24
PIPO-CADE, low CHFO	60	18	17	17	47	17
Mixed-con., high lg. trees	24	43	25	30	72	28
PSME-PILA	16	26	36	19	43	20
AB sp., high large trees	3	0	22	30	79	20
Average (w/out Shrub)	267	39	26	16	48	17
SSPM – Baja CA	25	-	-	19	94	25



Historical inventory transects by large tree (>24 in dbh) density class



Comparison to recent study using GLO data to capture historical forest conditions

Variable	Ponderosa	Mixed-conifer	White/red fir	Overall*
Tree density (ha^{-1}) [ac]	53 [21]	72 [29]	79 [32]	54 [22]
Basal area(m^2 ha^{-1}) [ft^2]	17 [74]	30 [130]	30 [130]	19 [83]

ESA ECOSPHERE

	Northern Sierra Nevada				Southern Sierra Nevada				
Variable	Ponderosa	Mixed conifer	White fir	Overall	Ponderosa	Mixed conifer	White fir	Overall	Pooled
Area (ha)									
Openings†	8981	9871	4417	23269	10602	15485	7014	33101	. . .‡
Scattered trees§	2006	3425	779	6210	1539	3819	1984	7342	. . .
Forested area¶	25478	55917	19291	100686	31649	65856	43865	141370	. . .
Total area	36465	69213	24487	130165	43790	85160	52863	181813	. . .
Percentage in openings/scattered	30.1	19.2	21.2	22.6	27.7	22.7	17.0	22.2	. . .
Forest density (trees/ha)									
Mean	331	346	263	318	260	277	308	275	293
SD	463	379	259	337	227	620	793	558	477
Minimum	71	55	55	55	85	47	47	47	47
First quartile	151	179	124	163	143	122	117	123	139
Median	213	239	204	229	201	191	179	191	206
Third quartile	362	378	314	360	288	275	277	278	312
Maximum	2880	2880	1989	2880	1932	9147	9147	9147	9147
n	83	170	65	234	117	231	145	314	548
t (mean = 150 trees/ha)	3.56	6.75	3.51	7.61	5.21	3.11	2.40	3.95	7.02
p	0.001	<0.001	0.001	<0.001	<0.001	0.002	0.018	<0.001	<0.001
Basal area (m^2/ha)									
Mean	27.9	35.4	40.5	32.5	33.6	36.9	39.1	35.5	
SD	15.5	21.4	22.0	20.0	19.4	26.4	30.8	25.6	
Minimum	5.7	1.2	7.1	1.2	12.8	6.5	4.4	4.4	
First quartile	16.2	20.4	25.7	18.7	23.1	24.4	22.4	21.7	
Median	25.1	32.0	37.9	29.2	28.8	32.8	32.7	30.4	
Third quartile	39.6	46.0	49.6	43.6	37.7	42.5	49.8	42.7	
Maximum	61.2	120.6	120.6	120.6	146.9	246.3	246.3	246.3	
n	48	116	39	175	68	140	87	235	
t (mean = 33.2 m^2/ha)	2.35	1.09	2.08	0.97	0.17	1.66	1.79	2.34	
p	0.023	0.279	0.044	0.355	0.866	0.099	0.076	0.020	

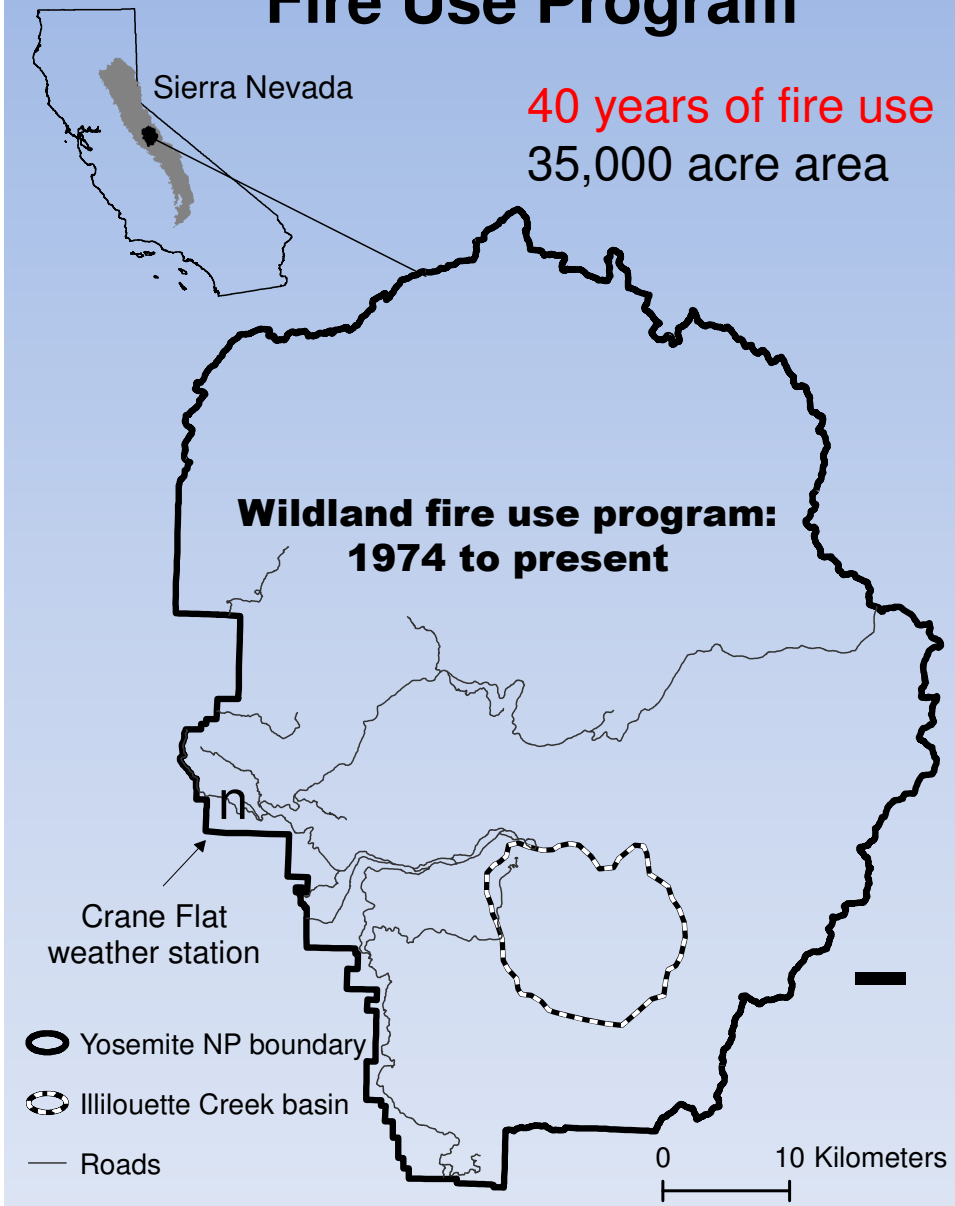
Forest management implications:

- **Historical forests were very low density, yet highly variable**
  - **Patches of high density-yes**
- **Topography/landform was a driving factor, but not only one**
  - **Fire interacted with vegetation (and topo) to produce the considerable range in forest structure**

- **Landscape-scale restoration strategies are needed**
  - ***Where feasible* fire use should be incorporated, also mech and prescribed fire treatments**

➢ **Kern National Forest Greenhorn Mountains (Stephens et al. 2015)**

Yosemite National Park Fire Use Program



Collins and Stephens, 2007 *Front. Ecol. Environ.*

2001 Hoover Fire Yosemite National Park

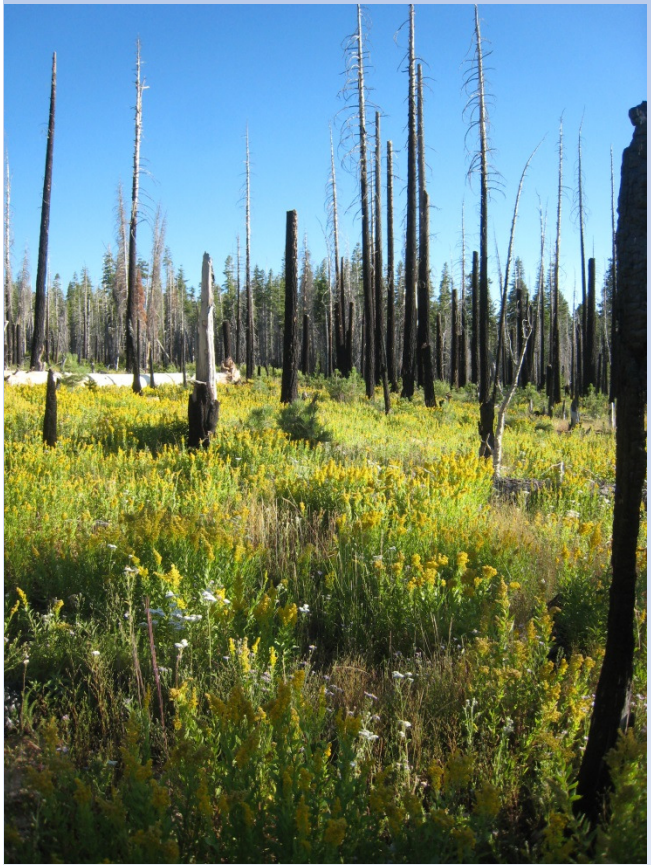
Illilouette Creek Basin

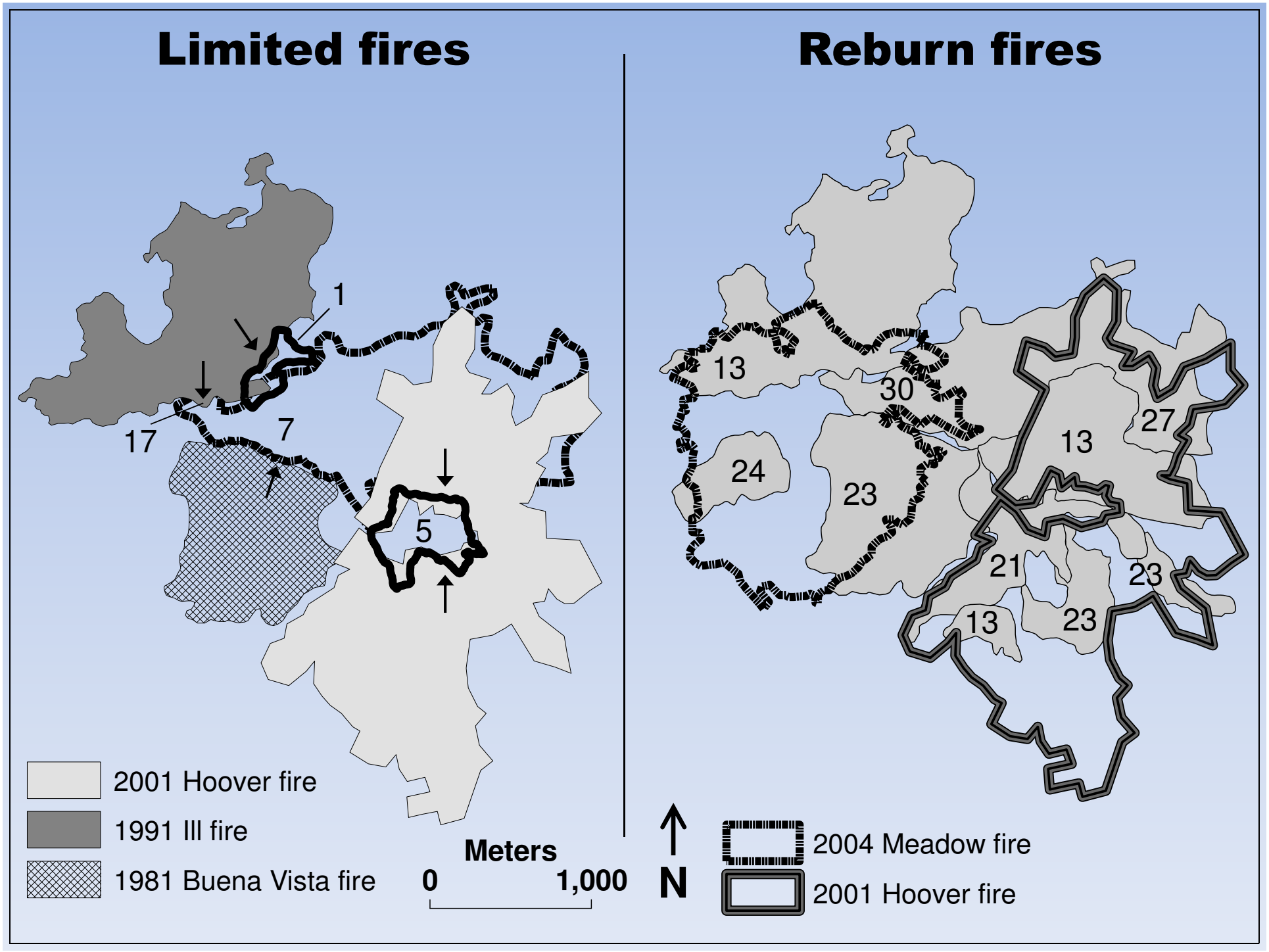
Low, moderate, and high severity fire since 1974

- **Based on remotely sensed data (landsat) and field plots**

More on forest patches a bit later

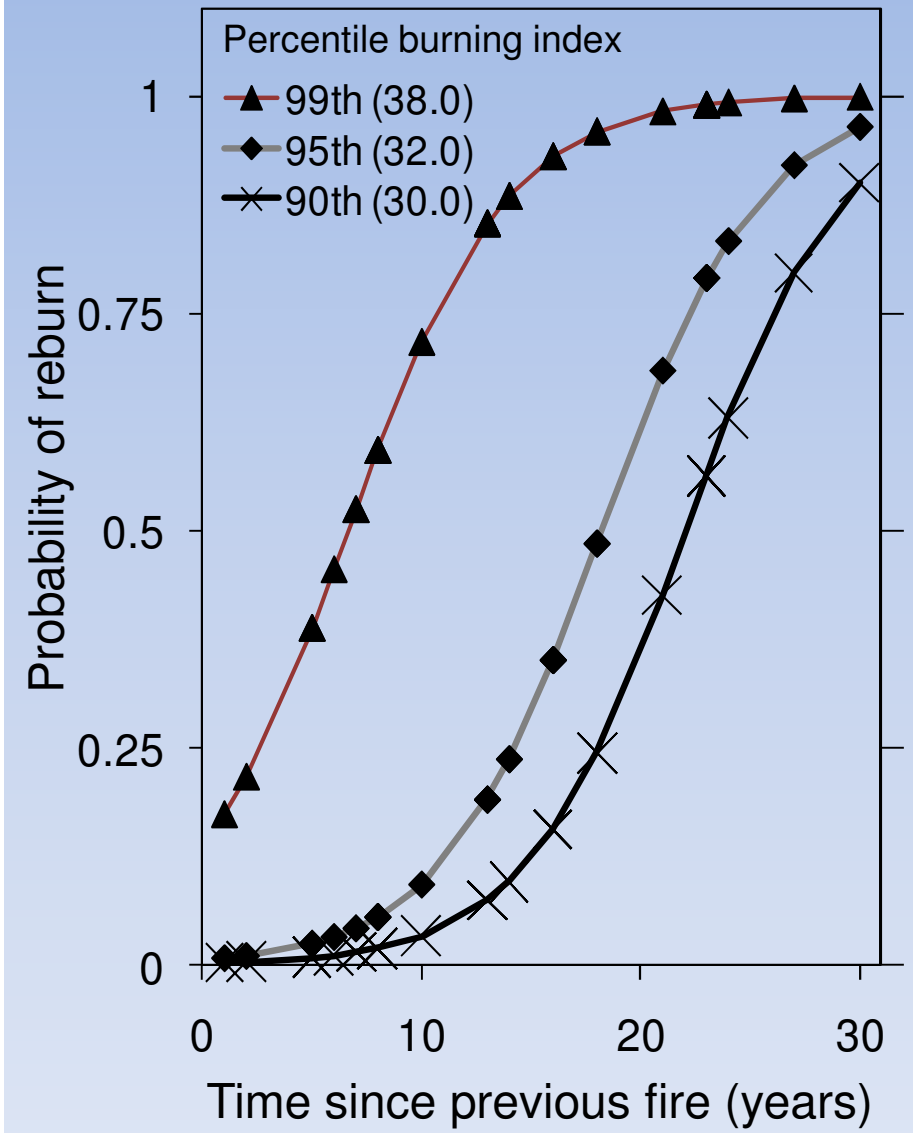
Noticed change in surface water after patchy high severity fire



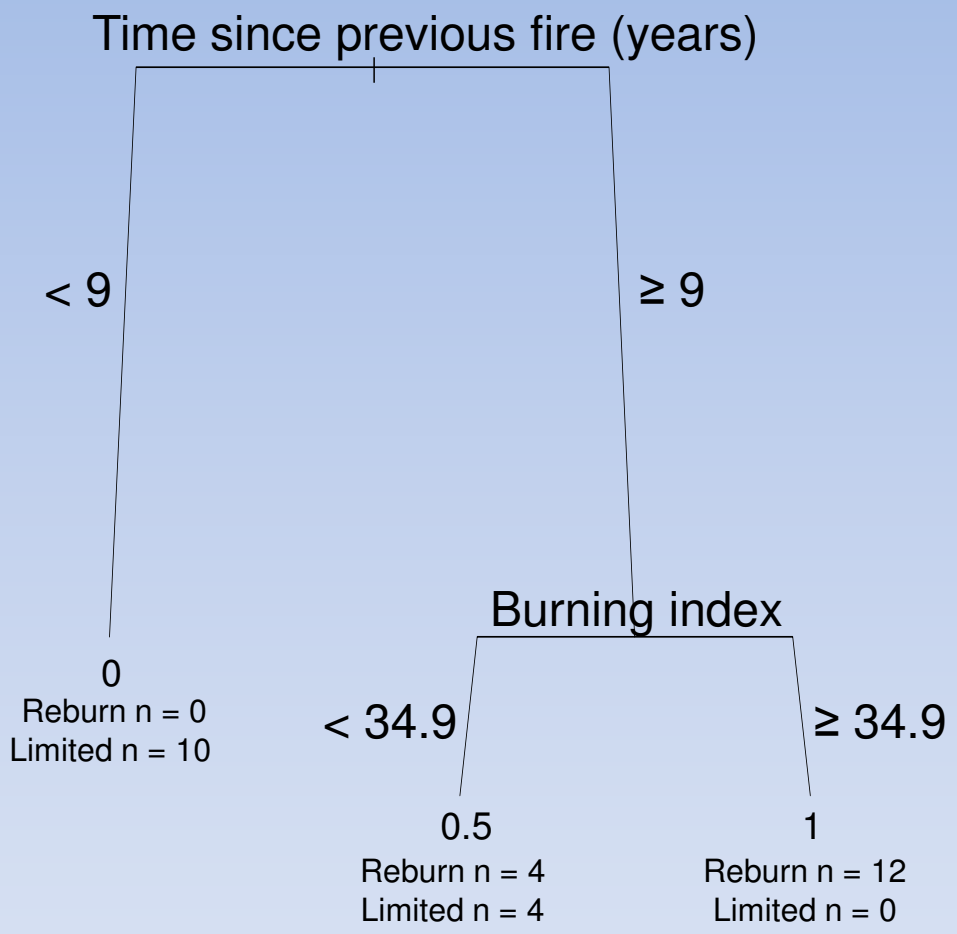

Limited fires
Reburn fires
1
17
7
5
13
30
27
13
24
23
21
23
13
23
2001 Hoover fire
1991 Ill fire
1981 Buena Vista fire
Meters
0
1,000
N
2004 Meadow fire
2001 Hoover fire

Interactions between adjacent fires

Logistic regression



Categorical tree

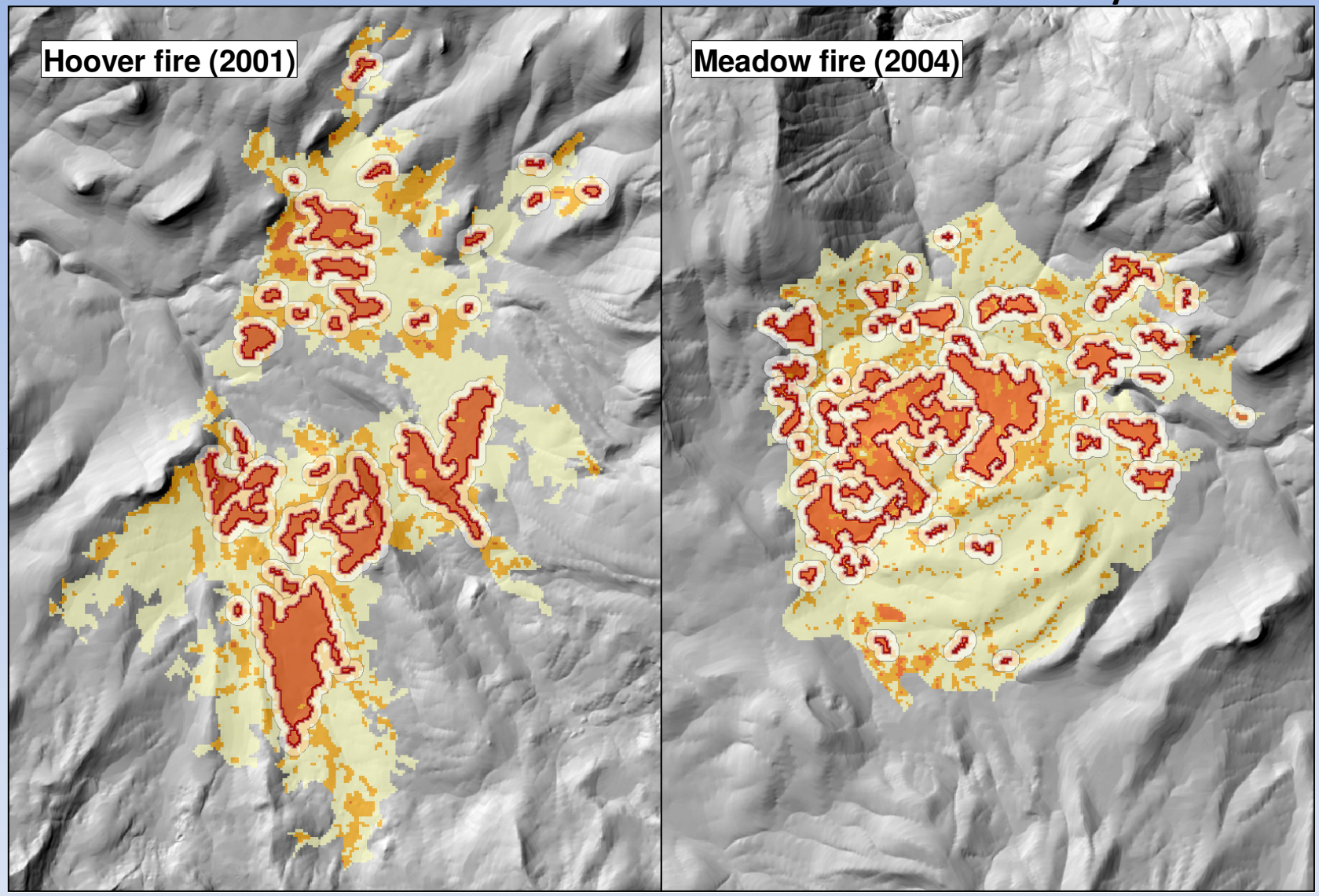


Frequency of treatment in similar systems - high

Collins et al., 2009 *Ecosystems*

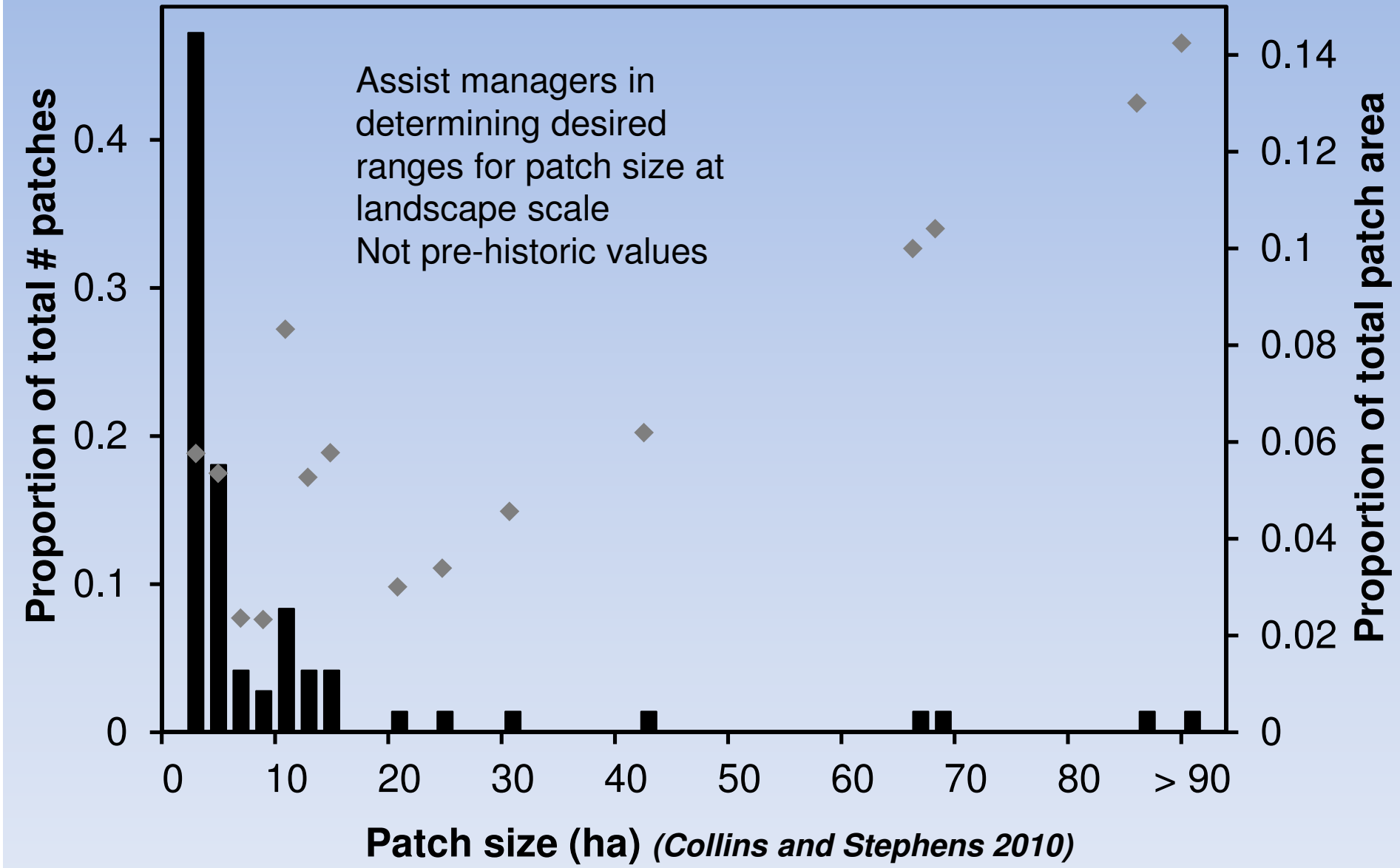
Controls on stand-replacing patches

Illilouette Creek basin – Yosemite NP – RdNBR Burn Severity



Stand-replacing patches: Hoover and Meadow fires

(Median high severity patch size < 4ha)



(Collins and Stephens 2010)

Fire, Hydrology, and Carbon in the Sierra Nevada – Possible Triple Win

Water resources critical to Western States

- Cities, industry, aquatic habitats

Snow melt is occurring earlier in California

- Warming temperatures key factor

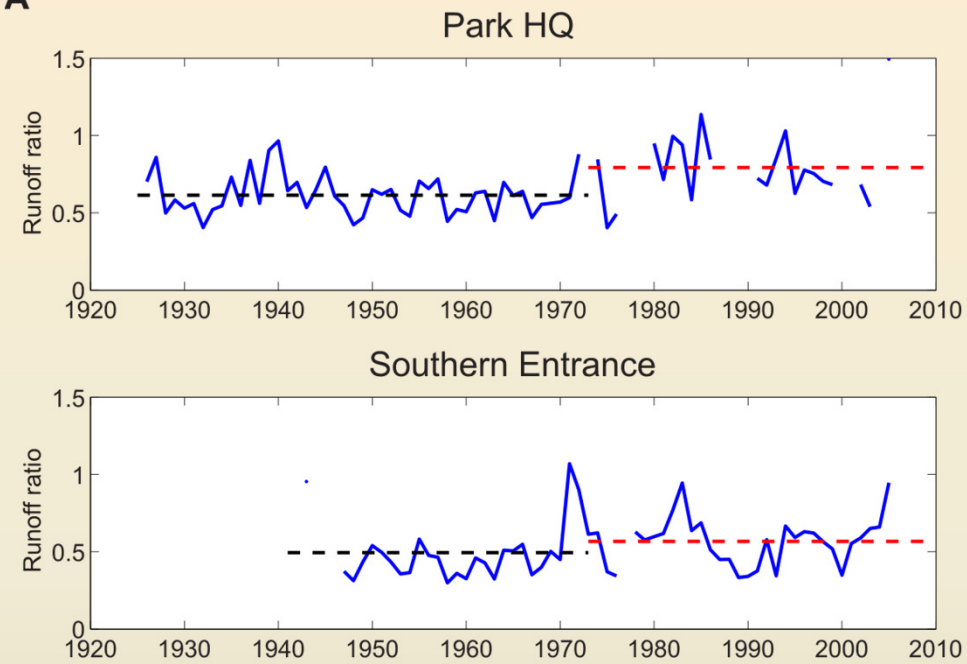
Timing of flow also critical

- Some small streams may dry out in future

Can fire be used to benefit hydrology?

Illilouette Creek Basin Watershed

A



B

Runoff coefficient (amount of stream flow output per unit input of water)
Experienced a significant increase with the onset of the fire use program in the mid 1970's in Illilouete Creek Basin – forest resilience increased too
In some areas mesic vegetation is replacing dry forests and water tables are increasing. Forest resiliency is also increased by fire program.
Additional research needed in this area. VERY PROMISING INITIAL RESULT

CDF

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UC Berkeley

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