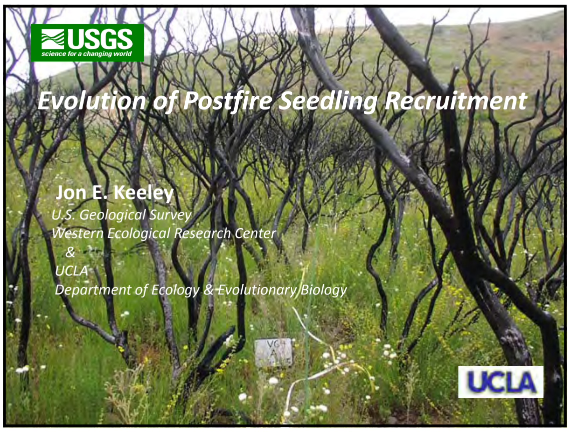

Evolution of Postfire Seedling Recruitment

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Paleozoic

Silurian (440 Ma) — Charred remains of low-growing vegetation of the earliest stomatal bearing plants, plus charred coprolites, indicate a low-temperature surface fire (Glasspool et al. 2004)

Devonian (395 Ma) — Pro-gymnosperm forests persisted with frequent fires that burned shrubs desiccated during the dry season (Cressler 2001)

Carboniferous (345 Ma) — Laminated deposits record fires 3-35 yrs in pro-gymnosperm communities under a monsoonal climate

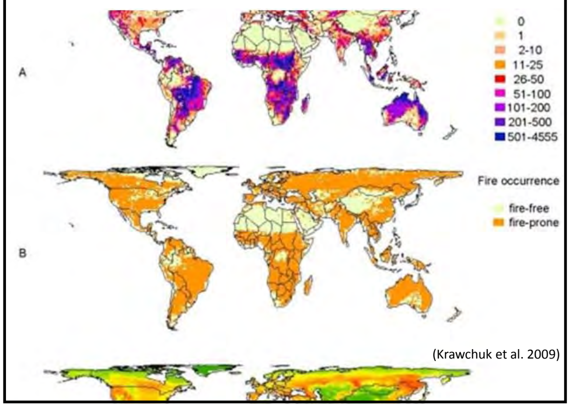
Wetland lepidodendron forests with fires 105-1585 yrs, charred apices indicate crown fires (Falcon-Lang 2000)

Mesozoic

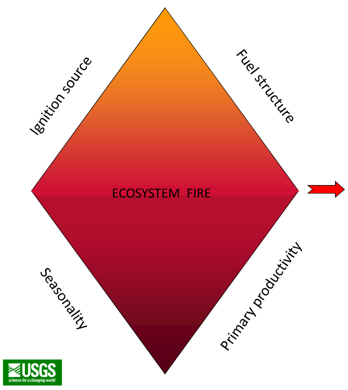
Jurassic (195 Ma) — Gymnosperm forests with tree ring patterns of a mediterranean climate – mild winter rain and summer drought, charred fragments provide evidence of light surface fires (Francis 1984)

Allen (1998): Cretaceous landscapes with 'fire-adapted "chaparral-like shrublands" (conifers, cycads, ferns) that supported diverse dinosaur faunas and with abundant evidence of periodic fires.

Charred remains interpreted as fire adaptations, including serotinous cones, fire-stimulated hard seeds, and highly sclerotic fern indusia that were dropped when heated by fire.



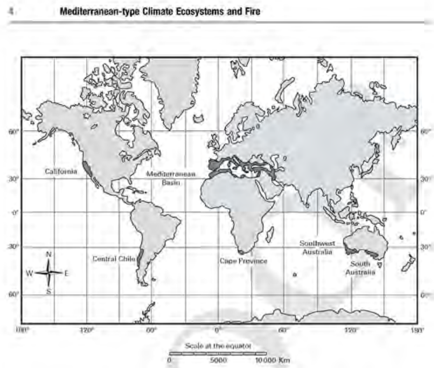
(Krawchuk et al. 2009)



Fire Regime

- Fuels consumed
- Fire frequency
- Fire intensity
- Fire season
- Fire response


Photo: Chris Doolittle



(Keeley, Bond, Bradstock, Pausas, Rundel 2012

Recruitment on fire-prone landscapes

– **Q1: Continuous vs delayed recruitment**
  e.g. *Rhamnus* vs *Ceanothus*

No postfire recruitment
(postfire obligate resprouters)

Pulse of postfire seedlings
(postfire seeders)

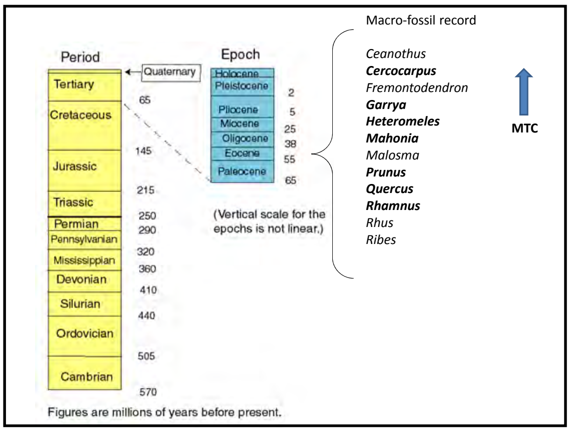
Recruitment on fire-prone landscapes

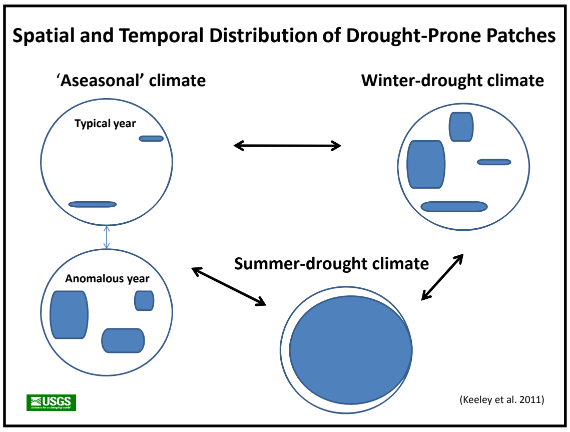
– **Q1: Continuous vs delayed recruitment**

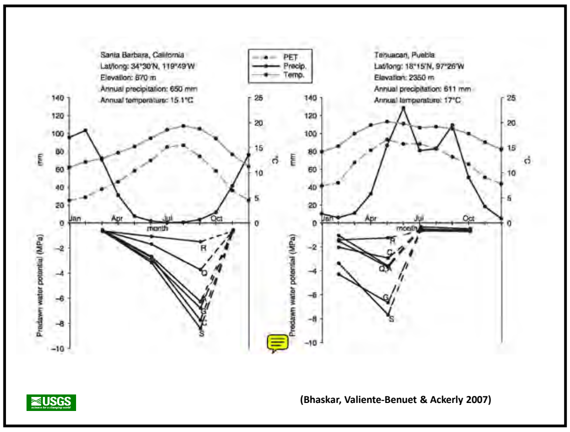
Many theories:

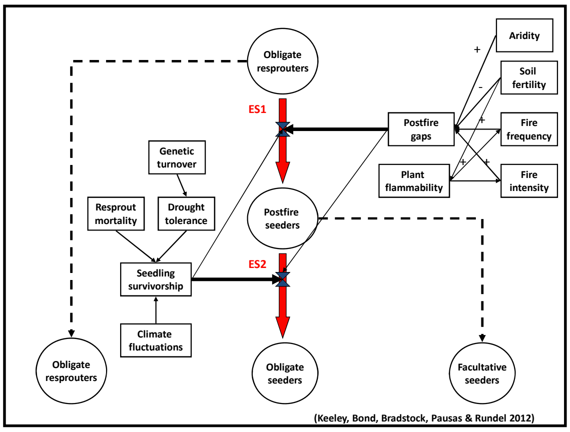
1) Lack of postfire seeding is a reflection of pre-MTC origins, i.e., "non-adaptive …ecological phantoms…unchanged in the face of changing ecological conditions"

2) Fire-prone landscapes provide multiple selective peaks favoring both continuous and delayed reproduction









Stresses or traits	Obligate resprouters (see Table 3.1)	Obligate seeders (see Table 3.4)
Water stress mode:	Avoiders (anisohydric)	Tolerators (isohydric)
Mechanism:	morphological (deep roots)	anatomical physiological
Potential drought-induced mortality:		
-- Adults	very low	moderate
--Seedlings	very high	moderate
Recruitment mode:	disturbance-free	disturbance-dependent
Safe sites	under canopy	burned sites
Availability		
--In time:	1 yr	10 – 100 yr
--In space:	limited	extensive
Seed dormancy	weak/no	deep
Seed bank:	transient (< 1 yr)	persistent (10 - 100 yr)
Germination cues*	none	heat shock or chemicals from char or smoke
Dispersal strategy:	spatial	temporal
--Mode:	vertebrates	passive or invertebrates
--Shadow:	wide	narrow
--Season:	fall–winter	spring–summer
Seed size:	large	small
Ecological pattern		
--Niche width:	wide	narrow
Biogeographical distribution:	widespread	localized
Origin:	early Tertiary	early Tertiary – Quaternary

* many species from both life histories may have a cold stratification requirement

(Keeley, Bond, Bradstock, Pausas & Rundel 2012)

Recruitment on fire-prone landscapes

– **Q2: Facultative vs obligate seeding**

e.g. *Ceanothus* subg vs *Cerastes* subg

Recruitment on fire-prone landscapes

– **Q2: Facultative vs obligate seeding**

Factors selection for obligate seeding
Analogous to tradeoffs between semelparity and iteroparity (where fire cycles ~ annual)
Charnov & Shaffer (1973) iteroparity selected for when P/C >>1

→ Resprouting success is high and/or
→ Seedling recruitment success is low

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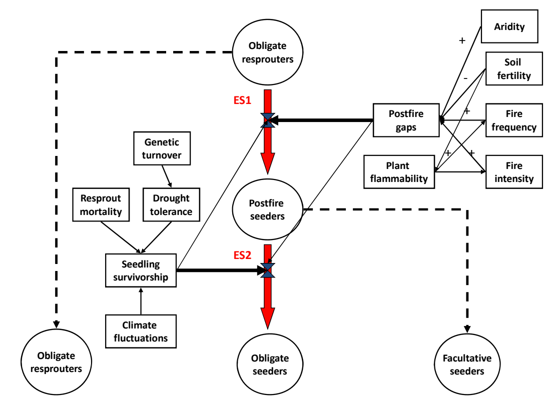


(Keeley, Bond, Bradstock, Pausas & Rundel 2012)

Recruitment on fire-prone landscapes

– **Q3: Soil storage vs canopy storage**

e.g. *Adenostoma* vs *Protea*

Recruitment on fire-prone landscapes

– **Q3: Soil storage vs canopy storage**

Why the discrepancy in distribution of serotiny between northern and southern hemispheres?

Many theories:

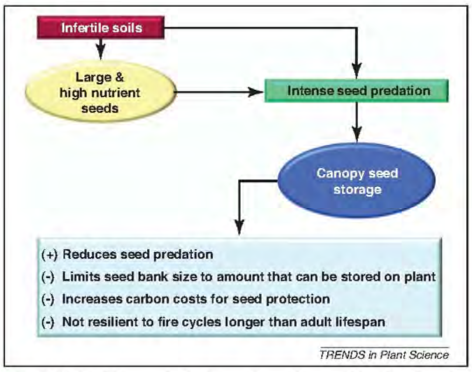
1) Higher rainfall predictability favors serotiny

2) Higher surface seed predation favors serotiny

Species	Life form[3]	Chaparral # sites	Chaparral $\bar{X} \pm$ S.E.	Sage scrub # sites	Sage scrub $\bar{X} \pm$ S.E.	Percentage by year 1	2	3	4	5
Obligate-Seeders										
Ceanothus crassifolius	s	10	62,100 ± 17,800	3	1,500 ± 800	99	1	0	0	0
C. cuneatus	s	1	14,000	2	9,800 ± 9,800	97	3	0	0	0
C. greggii	s	8	18,500 ± 18,500	1	1,000	100	0	0	0	0
C. megacarpus	s	9	55,700 ± 24,200	2	11,000 ± 7,000	96	4	0	0	0
C. oliganthus	s	6	103,900 ± 95,500	0	-	100	0	0	0	0
C. tomentosus	s	2	56,300 ± 700	0	-	99	1	0	0	0
Dendromecon rigida	ss	1	53,000	0	-	95	5	0	0	0
Helianthemum scoparium	su	12	33,500 ± 17,500	3	109,200 ± 75,200	73	13	7	0	7
Lotus scoparius	su	39	46,100 ± 8,400	43	77,600 ± 33,900	72	9	2	1	16
Facultative Seeders										
Adenostoma fasciculatum	s	31	104,500 ± 22,800	11	23,700 ± 12,700	94	3	0	0	3
Artemisia californica	ss	12	11,600 ± 4,800	41	31,500 ± 10,600	41	42	13	1	4
Calystegia macrostegia	su	25	49,700 ± 12,100	34	38,630 ± 7,200	92	5	2	0	1
Ceanothus spinosus	s	9	36,600 ± 25,100	1	2,000	92	3	0	0	5
Encelia farinosa	ss	0		8	21,100 ± 8,500	10	19	18	0	53
Eriodictyon crassifolium & E. trichocalyx	ss	4	3,100 ± 800	1	1,000	52	24	10	12	2
Eriophyllum confertiflorum	su	25	168,700 ± 42,900	30	24,000 ± 8,500	20	33	24	10	13

Total seedling recruitment for all 5 years (#/ha)

(Keeley, Fotheringham & Keeley 2006)



(Keeley, Pausas, Rundel, Bond, & Bradstock 2011)