

Supplementary Material

Disturbance history modulates how litter and herbaceous cover influence conifer regeneration after fire

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To explore model interaction terms over time, plots were classified by high and low percentages of litter cover in 2003 and herbaceous cover in 2005 (herbaceous cover was virtually absent across sites until 2005). High versus low litter/herbaceous cover distinctions were made according to ground cover percentage class such that the amount of data in the two categories would be represented by as close to equal amounts of data as possible within stand categories of species composition, structural stage, and recent disturbance history (Table S2). For herbaceous vegetation, this was a threshold of >25% coverage in 2005. For litter, this was a threshold of >50% coverage in 2003. Conifer regeneration and bare ground, litter, and herbaceous cover were then plotted in groups determined by these thresholds to depict context-specific relationships between tree regeneration and ground cover (Figures S6-S7).

Table S1. Ground cover category definitions

Data were categorized by percent coverage in 900 2 × 1 m plots throughout burned stands of various pre-fire stage, composition, and disturbance history. In each plot, coverage was measured for bare ground, plant litter, herbaceous cover, shrubs, trees, and logs in 2003, 2004, 2005, 2010, and 2014.

Category	Description
Logs	Dead, fallen trees (<i>P. engelmannii</i> , <i>A. lasiocarpa</i> , <i>P. tremuloides</i> , <i>P. contorta</i>) with diameter ≥ 4 cm
Litter	Any dead organic material < 4 cm in diameter, including charcoal
Shrubs	Woody plants including <i>Arctostaphylos uva-ursi</i> , <i>Cirsium</i> spp., <i>Carduus</i> spp., <i>Mahonia aquifolium</i> , <i>Prunus</i> spp., <i>Rhododendron</i> spp., <i>Rubus</i> spp., <i>Vaccinium</i> spp.
Herbaceous	Non-woody plants including <i>Aquilegia caerulea</i> , <i>Arnica</i> spp., <i>Campanula</i> spp., <i>Carex</i> spp., <i>Chamaenerion</i> spp., <i>Delphinium</i> spp., <i>Fabaceae</i> spp., <i>Festuca</i> spp., <i>Hieracium albiflorum</i> , <i>Maianthemum racemosum</i> , <i>Poa</i> spp., <i>Rosa</i> spp., <i>Solidago</i> spp., <i>Trillium</i> spp.
Bare	Soil or rock
Trees	<i>P. engelmannii</i> , <i>A. lasiocarpa</i> , <i>P. tremuloides</i> , or <i>P. contorta</i>

Table S2. Plots categorized by percent litter and herbaceous cover

Counts of plots in each category based on prefire composition, structural stage, combination of recent disturbances (fire only, F; wind blowdown and fire, W+F; Spruce beetle outbreak and fire, SB+F) and ground cover class. Post-fire ground cover class distinctions were based on initial litter and herbaceous cover. Young stands burned within the last 200 years, while old stands are >200 yrs old. PIEN-ABLA indicates stands of mixed *P. engelmannii* and *A. lasiocarpa* before fire. PICO indicates stands with > 40% canopy dominance of *P. contorta* before fire.

Post-fire ground cover class	PIEN-		Young (F)	Old (F)	PIEN-		Young (W+F)	Old (W+F)	PIEN-	
	ABLA (F)	PICO (F)			ABLA (W+F)	PICO (W+F)			ABLA (SB+F)	PICO (SB+F)
High litter	103	94	127	70	26	41	20	47	21	17
Low litter	77	86	53	110	154	139	160	133	67	74
High herbaceous	32	77	84	25	13	77	46	44	33	62
Low herbaceous	148	103	96	155	167	103	134	136	12	28

Figure S1. *Abies lasiocarpa* regeneration density and litter cover in 2014, by combination of disturbances. F = 2002 fire only ($n = 360$). WF = 1997 wind blowdown and 2002 fire ($n = 360$). SBF = 1940s spruce beetle outbreak and 2002 fire ($n = 180$). Points are jittered to display overlapping data. Categories range from 0-5 (<1%, 1-5%, 6-25%, 26-50%, 51-75%, and >75%, respectively).

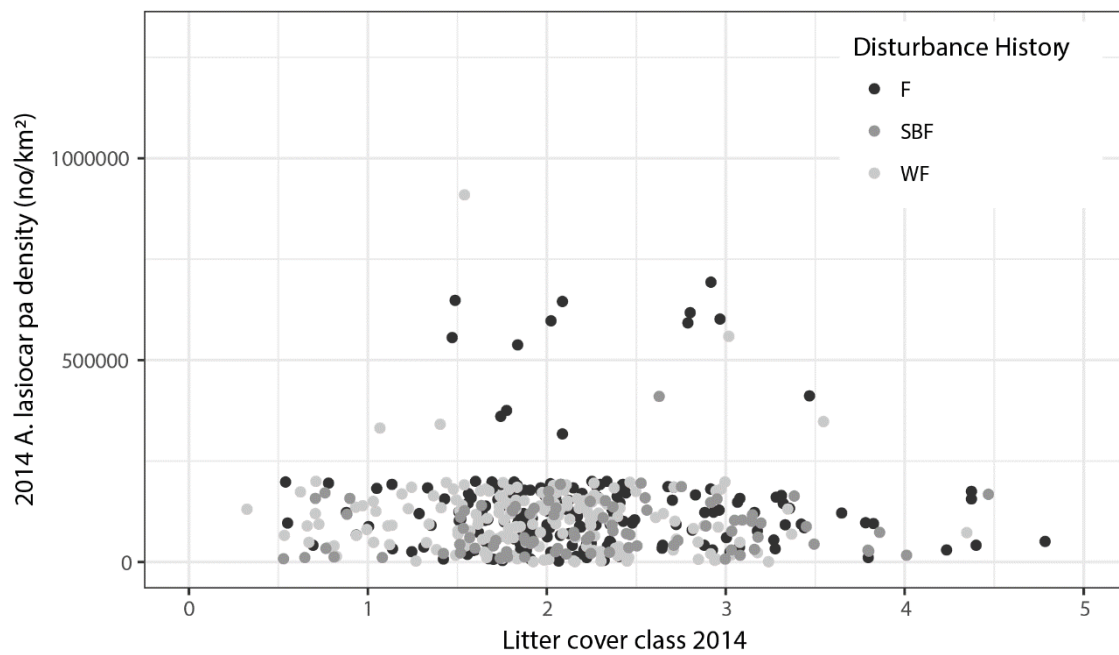


Figure S2. *Abies lasiocarpa* regeneration density and herbaceous cover in 2014, by combination of disturbances. F = 2002 fire only ($n = 360$). WF = 1997 wind blowdown and 2002 fire ($n = 360$). SBF = 1940s spruce beetle outbreak and 2002 fire ($n = 180$). Points are jittered to display overlapping data. Categories range from 0-5 (<1%, 1-5%, 6-25%, 26-50%, 51-75%, and >75%, respectively).

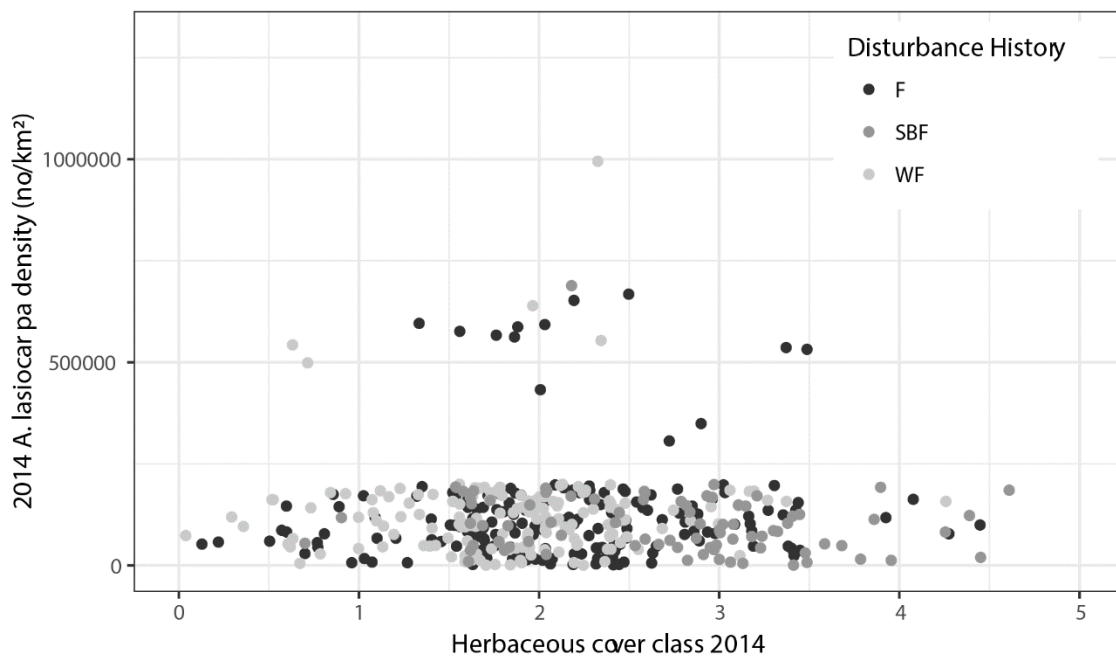


Figure S3. *Pinus contorta* regeneration density and litter cover in 2014, by combination of disturbances. F = 2002 fire only ($n = 360$). WF = 1997 wind blowdown and 2002 fire ($n = 360$). SBF = 1940s spruce beetle outbreak and 2002 fire ($n = 180$). Points are jittered to display overlapping data. Categories range from 0-5 (<1%, 1-5%, 6-25%, 26-50%, 51-75%, and >75%, respectively).

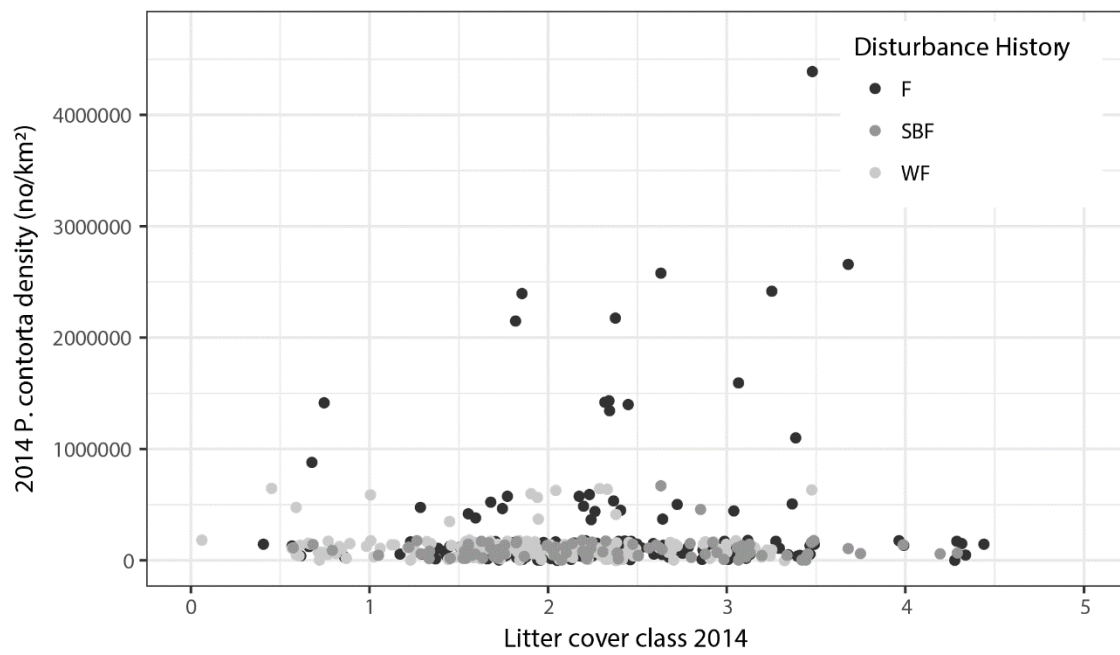


Figure S4. *Pinus contorta* regeneration density and herbaceous cover in 2014, by combination of disturbances. F = 2002 fire only ($n = 360$). WF = 1997 wind blowdown and 2002 fire ($n = 360$). SBF = 1940s spruce beetle outbreak and 2002 fire ($n = 180$). Points are jittered to display overlapping data. Categories range from 0-5 (<1%, 1-5%, 6-25%, 26-50%, 51-75%, and >75%, respectively).

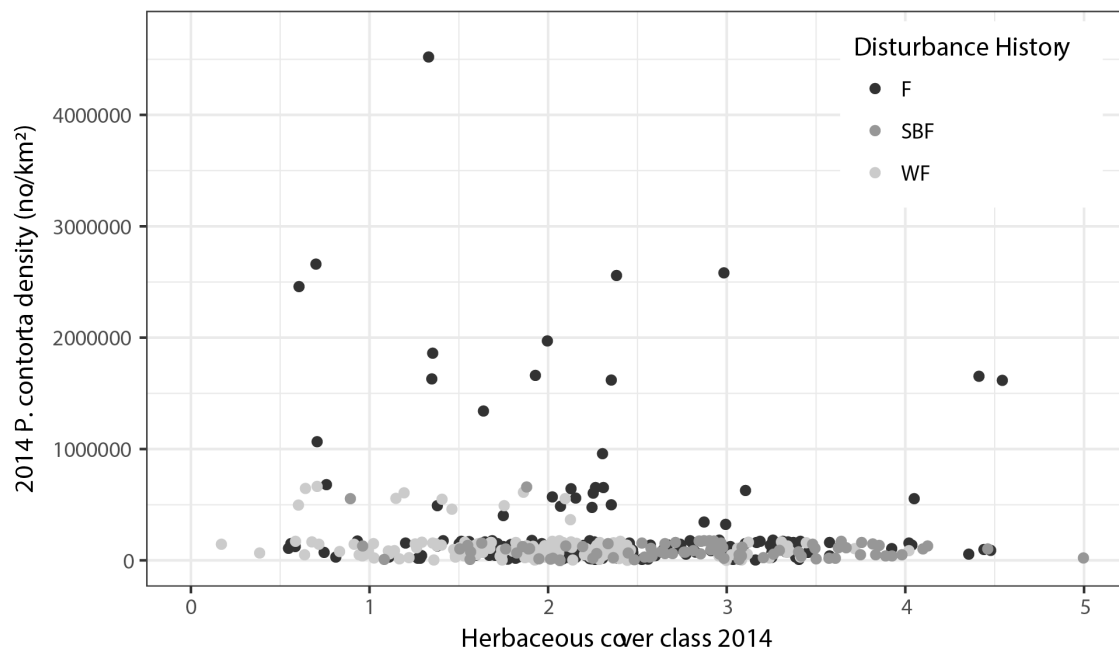


Figure S5. Scatterplots of regeneration and ground cover over time. Points are jittered to show overlapping data. *Abies lasiocarpa* and litter cover, 2005 (A) and 2010 (B). *Pinus contorta* and litter cover, 2005 (C) and 2010 (D). *Abies lasiocarpa* and herbaceous cover, 2005 (E) and 2010 (F). *Pinus contorta* and herbaceous cover, 2005 (G) and 2010 (H).

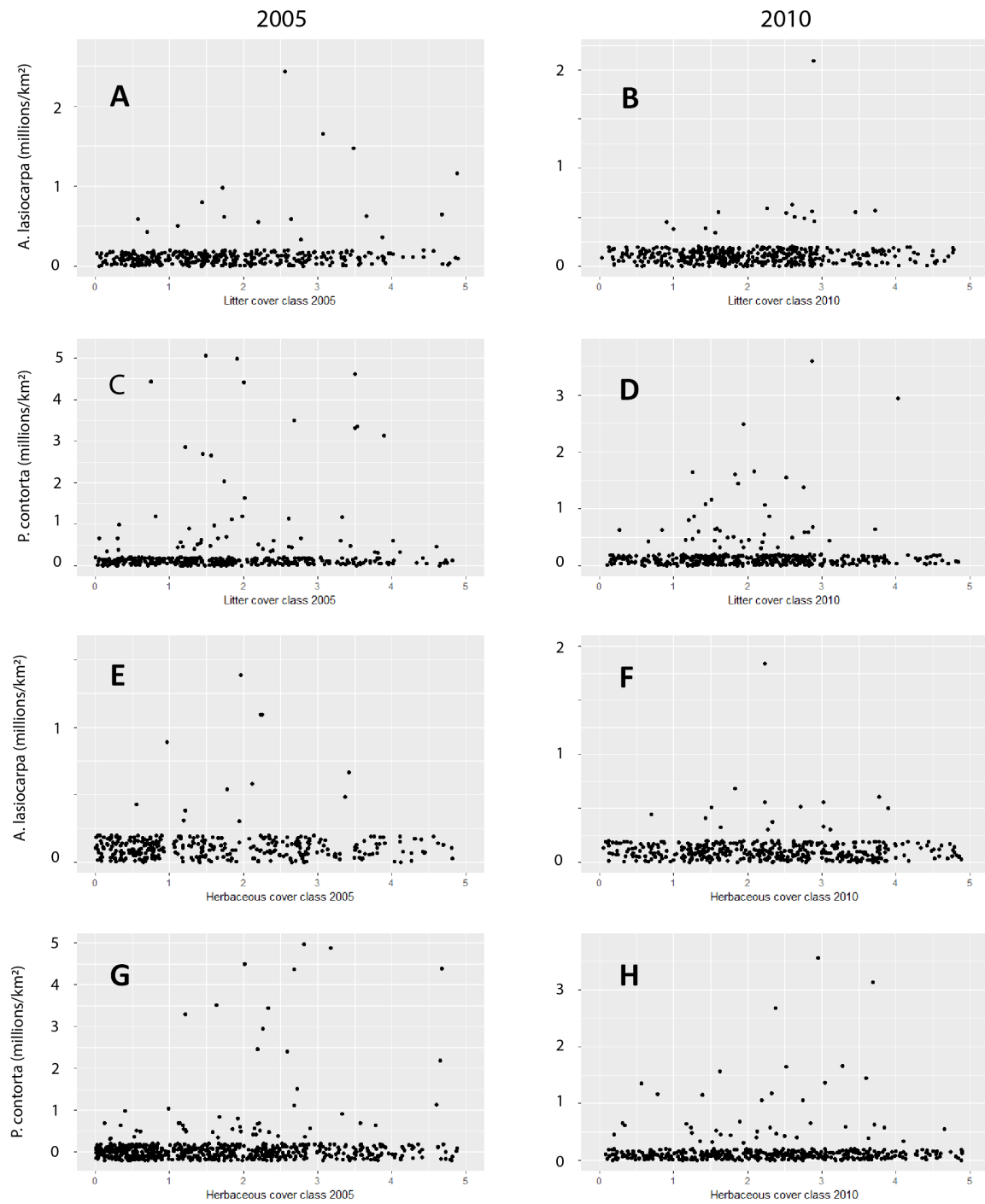


Figure S6. Relationship between post-fire conifer regeneration and litter coverage. Post-fire conifer regeneration densities (y-axis at right) and percentages of bare ground, litter, and herbaceous cover (y-axis at left) in *P. contorta* and mixed *P. engelmannii*-*A. lasiocarpa* stands from 2003-2014, separated by litter coverage, with high cover on the left and low on the right. A-B) Fire only; C-D) Blowdown-and-fire; E-F) SB outbreak-and-fire. Plots with >50% litter coverage in 2003 are at left (A, C, & E) while those with lower litter coverage are at right (B, D, & F). PICO = *P. contorta*; ABLA = *A. lasiocarpa*; PIEN = *P. engelmannii*.

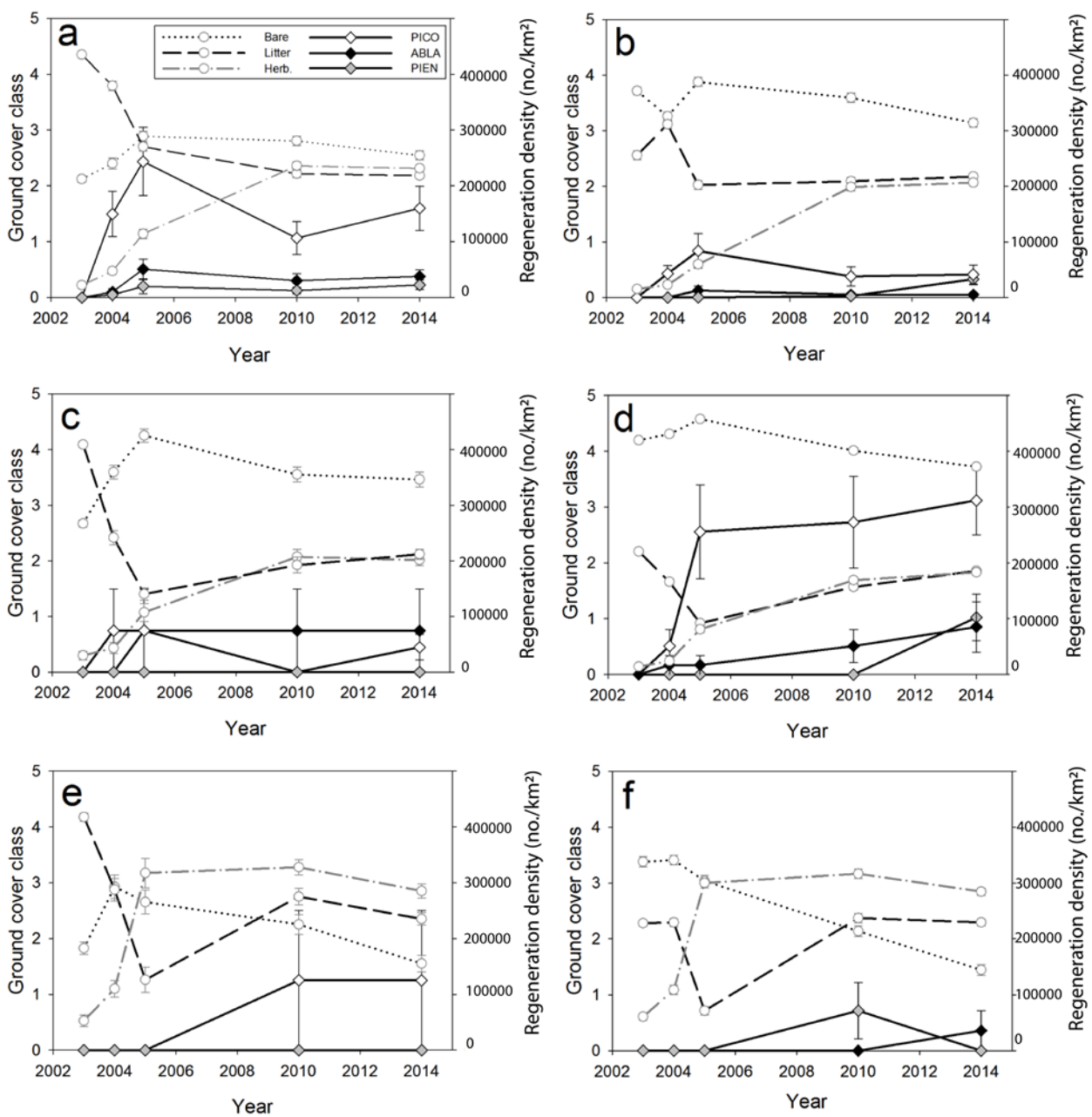


Figure S7. Relationship between post-fire conifer regeneration and herbaceous coverage. Post-fire conifer regeneration densities (y -axis at right) and percentages of bare ground, litter, and herbaceous cover (y -axis at left) in *P. contorta* and mixed *P. engelmannii*-*A. lasiocarpa* stands from 2003-2014, separated by herbaceous coverage, with high cover on the left and low on the right. A-B) Fire only; C-D) Blowdown-and-fire; E-F) SB outbreak-and-fire. Plots with >25% herbaceous coverage by 2005 are at left (A, C, & E) while those with lower herbaceous coverage are at right (B, D, & F). PICO = *P. contorta*; ABLA = *A. lasiocarpa*; PIEN = *P. engelmannii*.

