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Fire climate interactions and predicting fire season severity in the Mediterranean Climate Areas of California, southern Oregon, and Western Nevada

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Project Title: Fire climate interactions and predicting fire season severity in the Mediterranean Climate Areas of California, southern Oregon, and Western Nevada

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Project Locations: We collected and synthesized data on fire extent and climate in the Pacific Coast States of California, Oregon, and Washington. Our central focus was on fire-climate interactions in the region from southern Oregon south to Baja California. The period of analysis for this research includes both the contemporary period with instrumental climate data and written fire records, and a pre-instrumental period with proxy climate and fire data derived from tree rings. Tree-ring data were from both federal (16 National Forests, 2 National Parks, 1 National Monument, 1 National Recreation Area) and private lands (Sierra Pacific Industries). Some information on fire extent in the Sierra San Pedro Martir NP, Baja California was also included. Research was conducted at The Pennsylvania State University, Centre County, University Park, PA, Fifth Congressional District; USDA Forest Service, Pacific Southwest Research Station, Shasta County, Redding, CA, Second Congressional District; University of California, Alameda County, Berkeley, CA, Ninth Congressional District.

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SUMMARY OF FINDINGS TO DATE

Fire extent and climate in the Pacific Coast states: regional patterns and climate drivers (Contemporary Records & Instrumental Data1929-2004)

- We identified annual area burned for 37 National Forests in Washington, Oregon, and California between 1929 and 2004 from annual fire reports. Variation in area burned each year on National Forest lands is strongly related ($r^2 = 0.87$) to total area burned in California. This indicates area burned in National Forests is a good indicator of total area burned in a state.

- Four large groups of National Forests were identified that had similar temporal patterns of fire extent. Three of these groups were spatially coherent and included mainly: 1) Washington and northern Oregon; 2) northern California and California Coast Ranges; 3) southern Oregon. The fourth group consists of National Forests in each state adjacent to areas with relatively high populations, heavy travel corridors, and dry summers.

- The areas of western Washington, southwestern Oregon, and northern California are each primarily represented by a single group of National Forests. These areas receive more precipitation and heavier fuels associated with conifer forests than National Forests to the east and south so fire years are more synchronized by dry years in these areas than in the drier climates were fuels are dry enough to burn most years.

- Average summer Palmer Drought Severity Index (PDSI) was lower (drier) in years with large fires in each National Forest Group. The difference in summer PDSI between large and small fire years was strongest for Washington and northern Oregon and weakest in northern California where dry summer conditions prevail in most years and extensive fires are associated with outbreaks of dry lightning.

- Average annual PDSI and average winter and spring PDSI preceding the summer fire season were lower in years with large fires. Thus, dry winter and spring conditions, as reflected by PDSI, are an indicator of dry summers associated with large fire years.

- Atmospheric circulation patterns in years with high and low annual area burned were consistent across National Forest Groups. Years with large fires are associated with positive anomalies of geopotential height (700 h Pa) over the eastern North Pacific. This high pressure ridge weakens zonal westerly flow, blocks moist marine air from the eastern Pacific, and reduces winter precipitation.

- In the winter and spring preceding large fire years, the ridge is associated with a deepened Aleutian Low that may be displaced westward. Thus, years with large fires occur after a multi-season period of atmospheric conditions that reduce precipitation.

- The trough and ridge pattern over the North Pacific and North America in large fire years resembles the positive Pacific North America (PNA) teleconnection pattern. Large fire years are also associated with a positive PNA in the Pacific Northwest and western Canada.

- Years of limited fire activity are associated with the reverse PNA mode for North America. A weaker Aleutian Low and negative geopotential height anomalies over the west coast enhance convergence and uplift of marine air that results in above normal precipitation on the west coast.

- The weakened Aleutian Low pattern resembles a cool or negative phase of the Pacific Decadal Oscillation (PDO). During a warm of positive PDO phase conditions are reversed. Large fire years in the Pacific Northwest are associated with positive PDO. This work suggests that the influence of the PDO on fire extent covers the entire Pacific coast including California and northwestern Mexico.

Inter-annual Variation in Fire Weather, Fire Extent, and Atmospheric Circulation in Northern California and Oregon (1961-2000). This region was chosen for a more detailed analysis because it has a history of large wildfires and it straddles the pivotal latitude of the ENSO-PDO dipole. In the pivot zone, fires appear to be synchronized with the Pacific Northwest in some decades and with the southwest in others.

- We identified the influence of modes of atmospheric circulation including the El Niño-Southern Oscillation (ENSO, NINO3.4), PDO, and PNA on year-to-year variability in surface fire weather and fire extent in northern California and Oregon.

- Between 1961 and 2000 the average number of days with a Haines Index (HI) ≥5 (moderate-high fire growth potential) was 6 in winter and 15 in summer while the average number of days with HI ≤3 (very low potential) was 49 in summer and 71 in winter.

- There was a positive correlation between annual area burned and average annual values of HI and Energy Release Component (ERC) in both National Forest Groups. The relationship between annual area burned was stronger for fire season and annual HI than for HI in other seasons. Thus, annual area burned increased in years with a large number of high fire danger days as reflected by values of HI and ERC.

- Percentage of variability in annual area burned by ERC is modest (20%) but similar to the PDSI drought index. Variance in annual area burned by HI was higher than for ERC or PDSI (35%).

- Year to year variation in HI and ERC was associated with some modes of atmospheric circulation but not others. Annual HI and ERC for both regions were positively correlated with the winter PDO index. Drier and warmer conditions associated with a positive PDO promote more severe fire weather conditions.

- Year to year variation in annual HI was positively correlated with winter PNA. Annual HI was higher in years with a positive PNA anomaly then in years with negative anomalies. The relationship between PNA and ERC was more complex.

November PNA was positively correlated with ERC in Oregon and September PNA was negatively correlated with ERC in northern California.

- There was no association between concurrent year-to-year variation in HI or ERC and ENSO. However, annual HI and ERC were high three years after a La Niña phase. This may be an artifact of the ENSO cycle.
- Atmospheric circulation patterns in years with high HI and years of low HI had opposite anomalies of geopotential height (700 hPa) compared to the long-term average. A strong positive PNA mode occurred during years with high HI. An intensification of the Continental Ridge and a deepening of the West Coast Trough, a northward displacement of the polar-front jet stream, and a deflection of moisture bearing weather systems to the north that reduces precipitation characterize a strong positive PNA mode. Increased subsidence of air in the ridge that is implied by the intensified PNA promotes higher surface temperatures, lower humidity, and drier conditions.
- In contrast to the above, years with low HI exhibit geopotential height anomalies that resemble the reverse PNA pattern with a weakened Continental Ridge and West Coast Trough. This pattern is accompanied by zonal flow and wetter than normal conditions.
- Years of high ERC and years with low ERC in both Oregon and northern California have geopotential height patterns similar to years with high HI and years of low HI respectively. High ERC years are characterized by the positive PNA pattern except the center of the positive anomaly is further north. On the other hand, the trough over the eastern Pacific and the west coast is deepened in low ERC years, but there is a positive anomaly located over northwest Canada and Alaska.
- The positive anomaly over northwest Canada and Alaska indicates a higher-latitude blocking for these longitudes, or a reversal of the pressure/height departures from normal between middle and higher latitudes. Thus, the composite height patterns indicate that year-to-year variation in fire weather indices is related to annual variability in sub-hemispheric atmospheric circulation patterns.
- Inter-annual variability in fire weather indices in Oregon and northern California is related to synoptic scale circulation patterns, in particular the PNA pattern. The strongest influence of PNA on climate occurs in the winter months when it is best defined. Year-to-year variation in PNA had a stronger influence on HI than on ERC. This may result from a greater sensitivity of HI to temperature variation than for ERC. ERC may be primarily related to the influence of PNA on annual precipitation.

- Years when both HI and ERC are high were associated with widespread burning and particular modes of hemispheric atmospheric circulation. The 6 month or more time lag between fire danger potential as expressed by HI and ERC and prior winter atmospheric circulation (PNA, PDO) would permit fire managers to incorporate results into long term planning since they are measures of potential fire activity and not just drought. Moreover, climate indices are not currently used in fire planning and they provide useful information on potential fire activity in the winter before the fire season.

Inter-annual Variation in Fire extent, Climate, and Modes of Atmospheric Circulation (Data from fire scar record and dendrochronological reconstructions of climate indices 1700-1900)

- Our objective was to identify fire-climate relationships for the pre-instrumental period to determine if they were consistent with those in the contemporary period and to determine if other important relationships could be identified that may not show up in the short period of the contemporary record. Fire-climate relationships were identified between southern Oregon and northern Baja California for the period 1650-1900.

- Fire occurrence and extent were reconstructed from fire scars on 2,641 trees at 76 sites in six regions: the Klamath Mountains-North Coast Range (KM), Modoc-southern Cascades (M), northern Sierra Nevada (NSN), southern Sierra Nevada (SSN), southern California (SC), and northern Baja California (BC). Fire scarred trees came mainly from mixed conifer forests.

- Reconstructed fire years in each region and in the study area as a whole were compared to tree ring reconstructions of climate (Palmer Drought Severity Index-PDSI, summer temperature, TEMP) and modes of atmospheric circulation (i.e. Pacific North America Pattern-PNA, El Niño-Southern Oscillation-ENSO-NINO3, Pacific Decadal Oscillation-PDO, Atlantic Multidecadal Oscillation-AMO) known to influence climate in this region.

- Years of larger burns in each region were highly synchronous among regions suggesting a regional influence on fire extent such as climate. For example, over a 200-year period, only sixteen fire dates are expected to co-occur among five of the regions by chance, yet, our record had 80 such co-occurring fire dates.

- There was a positive correlation in indices of fire extent between regions, except for BC. The timing of fires in BC was independent of that in the other regions. Fire extent in SC was only weakly correlated with fire extent in KM and SSN. There was a strong correlation between years of high and years of low burning in NSN and SSN.

- The relationships between fire extent and PDSI and fire extent and TEMP were consistent between regions, except for SC and BC. Fire extent in each region was negatively correlated with PDSI except in SC. Similarly, fire extent was positively associated with TEMP except in BC. Thus, widespread burning is strongly associated with either drought or warm summer temperatures in regions other than SC and BC.

- Fire extent was correlated with modes of atmospheric circulation in some regions. In the NSN and SSN fire extent was positively correlated with the PNA and PDO and negatively correlated with the AMO. More importantly, PNA, and PDO are positively correlated with fire extent when regions are aggregated, except for SC and BC where variation in fire extent was independent of PNA and the PDO (as reconstructed by Gedalof & Smith). Similarly, when regions were aggregated, AMO was negatively correlated with fire extent, except in the south (SC+BC). ENSO was negatively correlated with fire extent in BC and variation in ENSO was not related to fire extent in other regions.

Interaction of Modes of Atmospheric Circulation on drought and large fire extent (Data from fire scar record and dendrochronological reconstructions of climate indices 1700-1900)

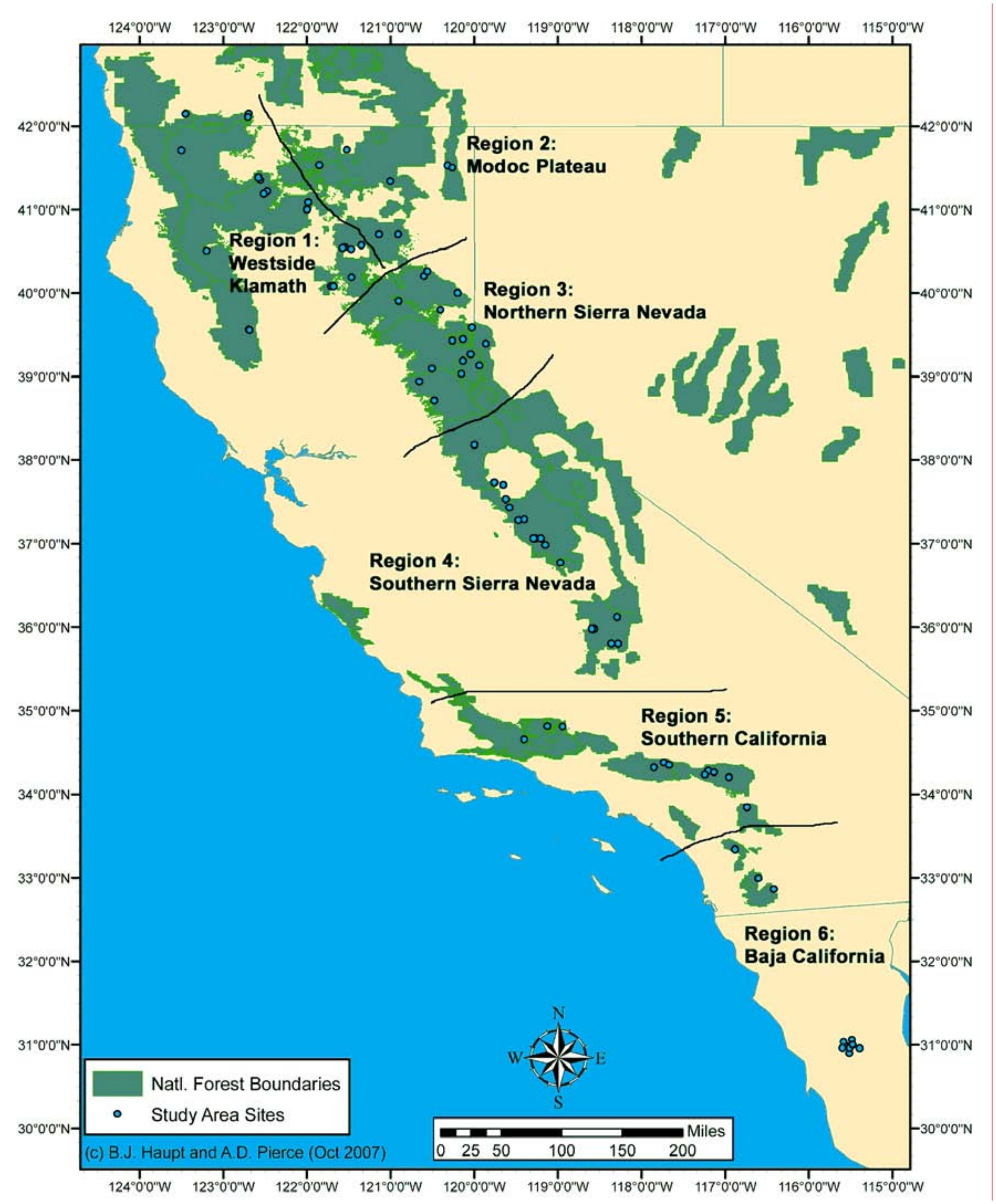
- Interactions among climate patterns (i.e. PNA, ENSO, PDO, AMO) influence the frequency and extent of drought and conditions conducive to widespread fire activity. We compared PDSI for positive (+) and negative (-) phase combinations for climate patterns for each region and among regions.

- Average PDSI varied depending on interactions between: 1) PDO, AMO, ENSO; 2) PDO, ENSO, PNA; 3) PDO, ENSO. Low PDSI (warm, dry) is associated with PDO+ and ENSO- in all regions, but the PNA and AMO amplify or dampen these effects on PDSI. For example, dry conditions during PDO+ and ENSO- conditions become drier with PNA+, or AMO+, except in BC. Dry conditions with ENSO- conditions and either + or - PNA, PDO, AMO reflects the stronger influence of ENSO on BC than in other regions

- We identified years of the largest 20 fires in each region and across regions and then compared them to climate phase combinations during these same years. Large fire years were associated with phase combinations that often lead to drought. For example, large fire years in most or all regions and across regions were associated with PNA+ ENSO-, PDO+ PNA+, PDO+, AMO-, PDO+ PNA+ ENSO-, PDO+AMO-, ENSO- conditions.

- Large fire occurrence in each region and across the study area was more strongly influenced by interactions among PNA, PDO, ENSO, and AMO than by individual modes of circulation. The statistical association between large fires and the different phases of modes of circulation indicate that use of climate indices could improve long lead forecasting of fire activity in the Mediterranean Climate Area of the Pacific Coast.

Map of fire-scar collection sites and climate regions used in the analyses. Note: some dots represent composites of several collection sites.



Interactions of climate indices and fire danger rating indices (Contemporary records 1958-2000). Three gridded sets of fire danger rating indices (Burning Index-BI, Energy Release Component-ERC, Canadian Fire Weather Index-FWI, and the Haines Index-HI) (each gridded to 0.5^O, 1^O, and 2^O of latitude) were created to cover the Pacific coast states of Washington, Oregon, California, and Nevada. Additionally, snow survey data (snow water equivalence-SWE) were gridded to the same scales. All fire danger indices were normalized with a mean of 0 and a standard deviation of 1 for each recording station in order to capture the variation of fire danger related to climate without the confounding effect of different fuel models affecting the absolute values of the fire danger rating indices.

- We used a multilevel linear mixed effects model approach to relate the gridded forest fire danger rating indices to the climate variables (Atlantic Multidecadal Oscillation-AMO, Arctic Oscillation-AO, North Atlantic Oscillation-NAO, El Nino Southern Oscillation-NINO3.4, Pacific Decadal Oscillation-PDO, Pacific North American Pattern-PNA, Southern Oscillation Index-SOI, and SWE).

- Further, each fire danger index was tested for interactions of both annual and summer conditions with antecedent conditions of the climate indices for 1) the preceding winter and 2) the previous1 and 2 years.

- The statistical association between fire danger rating indices and the suites of climate indices suggests that further refined models will help to improve long lead forecasting of potential fire activity in the Mediterranean Climate Area of the Pacific Coast. Though significant relationships were found between the fire danger indices and climate variables, further work is required to study the interactions of variables included in the models in order to simplify the models for use. Additionally, we need to further analyze the spatial relationships to better understand how the strength of the relationships varies geographically. Therefore, the following describes only the qualitative relationships found.

Results of modeling using all climate variables except for snow survey data.

- BI: Both the annual and the summer representations of BI were significantly related to the previous winter conditions of the climate indices. All indices were included in both models.

- BI: Both annual and summer BI were related to 1 and 2 year antecedent conditions of the climate variables. The variables included in both models were AMO, AO, PNA, and NINO3.4.

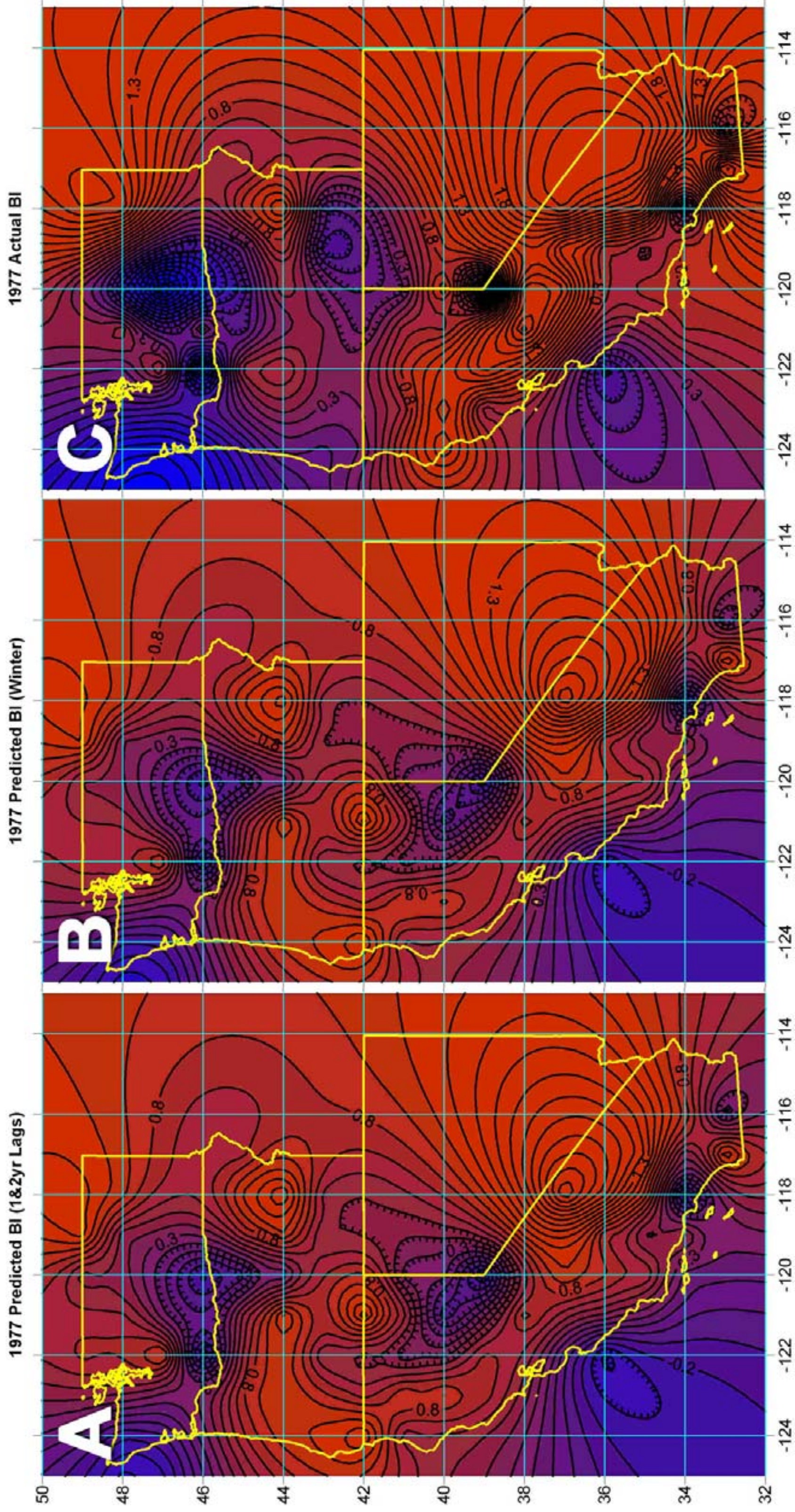
- ERC: Only the summer ERC was significantly related to both the 1) previous winter and 2) the 1 and 2 year antecedent conditions of the climate indices. All indices were included in the model.

- FWI: Only the annual FWI was significantly related to both the 1) previous winter and 2) the 1 and 2 year antecedent conditions of the climate indices. All indices were included in the model.
- HI: Both the annual and the summer representations of HI were significantly related to the previous winter conditions of the climate indices. SOI was not included in either model.
- HI: Only summer HI was related to 1 and 2 year antecedent conditions of the climate variables. All indices were included in the model.

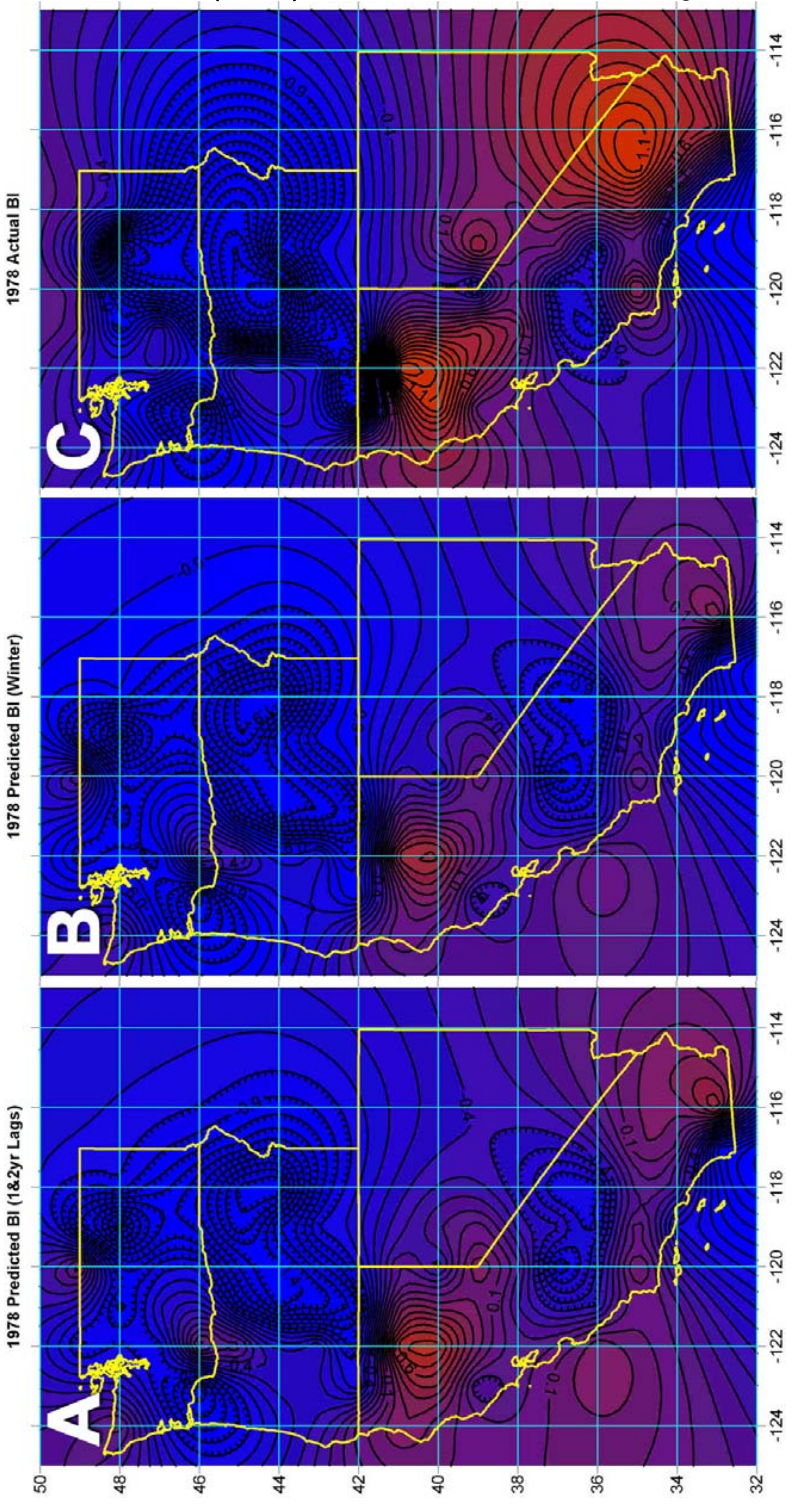
Results of modeling including the SWE data.

- BI: Both the annual and the summer representations of BI were significantly related to both the 1) previous winter and 2) the 1 and 2 year antecedent conditions of the climate indices. All indices were included in the model.
- ERC: Both annual and summer ERC were significantly related to the previous winter conditions of the climate indices. All indices were included in the annual model. SOI was not included in the summer model.
- ERC: Both annual and summer ERC were related to 1 and 2 year antecedent conditions of the climate variables. All indices were included in the model.
- FWI: Only the annual FWI was significantly related to both the 1) previous winter and 2) the 1 and 2 year antecedent conditions of the climate indices. All indices were included in the model.
- HI: Both the annual and the summer representations of HI were significantly related to the previous winter conditions of the climate indices. SOI was not included in either model.
- HI: Summer HI was related to 1 and 2 year antecedent conditions of the climate variables. All indices were included in the model.

Example of model outputs for 1977 – a year of widespread large fires. A = BI predicted from climate conditions 1 and 2 years previous; B = BI predicted from previous winter conditions (6mos); and C = actual BI. Red = High BI, Blue = Low BI



Example of model outputs for 1978 – a year of few widespread fires. A = BI predicted from climate conditions 1 and 2 years previous; B = BI predicted from previous winter conditions (6mos); and C = actual BI. Red = High BI, Blue = Low BI



Deliverables

Proposed	***Accomplished/Status***
Annual progress reports	Annual progress reports completed
Publications on fire/climate interactions – instrumental period	Smith, R., 2005. Relationships between climate and forest fire patterns in the U.S. west coast states, M.S. Thesis, Department of Geography, The Pennsylvania State University. Trouet, V., Taylor, A.H., Carleton, A.C., Skinner, C.N. 2006. Fire-climate interactions of the American Pacific Coast. *Geophysical Research Letters* 33, L18704, doi:10.1029/206GL027502 Trouet, V., Taylor, A.H., Carleton, A.C., Skinner, C.N. *In review.* Interannual variation in fire weather, fire extent, and Pacific teleconnections in northern California and Oregon. *Theoretical & Applied Climatology.*
Publications on fire/climate interactions – pre-instrumental period.	Guarin, A. and A.H. Taylor. 2005. Drought triggered tree mortality in mixed conifer forests in Yosemite National Park, California, USA. *Forest Ecology & Management* 218:229-244. Moody, T.J., Fites-Kaufman, J., Stephens, S.L. 2005. Fire history and climate influences from forests in the northern Sierra Nevada, USA. *Fire Ecology* 2: 115-142. Taylor, A.H. and R.M. Beaty. 2005. Climatic influences on fire regimes in the northern Sierra Nevada, Lake Tahoe, Nevada, USA. *Journal of Biogeography* 32: 425-438. Fry, D.L. and S.L. Stephens. 2006. Influence of humans and climate on the fire history of a ponderosa pine-mixed conifer forest in the southeastern Klamath Mountains, California. *Forest Ecology & Management* 223: 428-438. Gill, S. 2007 Spatial and temporal variation in fire regimes along a mixed conifer forest gradient in the Northern Sierra Nevada, California, M.S. Thesis, Department of Geography, The Pennsylvania State University Taylor, A.H., Trouet, V., Skinner, C.N. *In press.* Climatic influences on fire regimes in montane forests of the southern Cascades, California, USA. Invited paper for special issue fire/climate relationships of the *International Journal of Wildland Fire.* Beaty, M.R., Taylor, A.H. *In press* Fire history and the structure and dynamics of a mixed conifer forest landscape in the northern Sierra Nevada, Lake Tahoe Basin, California. *Forest Ecology & Management* Skinner, C.N., Burk, J.H., Barbour, M.G., Franco-Vizcaíno, E., Stephens, S.L. *In Review.* Influences of climate on fire regimes in montane forests of northwestern Mexico. *Journal of Biogeography*

Proposed	***Accomplished/Status***
Presentations – scientific audience	2003 Taylor, A.H. and R.M. Beaty. Climatic influences on fire regimes in the Lake Tahoe Basin. Second International Wildland Fire Ecology and Management Congress and Fifth Symposium on Fire and Forest Meteorology, Orlando Florida. 2004 Taylor, A.H. and R.M. Beaty. Climatic influences on fire regimes in the Lake Tahoe Basin. Association of American Geographers, Philadelphia, Pennsylvania. 2004. Skinner, C.N. USDA Forest Service Global Change/RPA All-Scientists Meeting. October 26-28. Welches, OR. Participant – provided synopsis of work on this project to date. 2005. Taylor, A.H., Skinner, C.N., Stephens, S.L. Fire history and climate synthesis in western North America. Northern Arizona University, Flagstaff, Arizona. USGS Global Change Program. Participants. 2005. Skinner, C.N., Taylor, A.H., Carleton, A.M., and Stephens, S.L. Fire-climate interactions and predicting fire season severity in the Mediterranean-climate areas of California, southwest Oregon, and western Nevada. Presentation to Principal Investigators Annual Meeting, Joint Fire Sciences Program, San Diego, California. 2005. Smith, R., Taylor, A.H., and A. Carleton. Spatial and temporal variations in precipitation in U.S. western coastal states and their relationship to atmospheric circulation. Association of American Geographers, Denver, Colorado. 2005. Trouet, V.M.L., Taylor, A.H., Smith, R., Carleton, A.M. Fire-climate interactions in the Mediterranean climate areas of California and Southern Oregon. Sixth Symposium on Fire and Forest Meteorology, Canmore, Alberta, Canada. 2005. Scholl, A., and A. H. Taylor. Climatic influences on fire regimes in Yosemite National Park, California. Association of American Geographers, Denver, Colorado. 2005. Skinner, C.N. Latitudinal gradient of fire regime responses to Pacific teleconnections in western North America. Open Science Conference: Global Change in Mountain Regions, 2 – 6 October, Perth, Scotland, UK. Third conference of the GLOCHAMORE project. Perth College, UHI, Perth, UK. 2005. Skinner, C.N. Influence of climate variation on fire regimes in the North American Mediterranean Climate Zone. Oregon State University, Corvallis. 2005. Taylor, A.H. Human and climatic influences on fire regimes in the Northern Sierra Nevada, USA. Department of Meteorology, The Pennsylvania State University 2006. Trouet, V. and A. H. Taylor. Fire-climate interactions in northern California. Tree Rings in Archaeology, Climatology, and Ecology (TRACE 2006). April 20-22, Tervuren, Belgium. 2006. Taylor, A.H. and Scholl, A.E. Human and climatic influences on fire regimes in Yosemite National Park, USA. Yosemite National Park, Fire Science Symposium, Yosemite Village, CA. May 4-6, 2006 2006. Taylor, A.H., Trouet, V., Skinner, C.N. Annual and Decadal Climatic Influences on Fire Regimes in Mid-Montane Conifer Forests in the Southern Cascades. In: 3rd International Fire Ecology & Management Congress, 13-17 November 2006, San Diego, CA. Association for Fire Ecology. 2006. Trouet, V., Taylor, A.H., and Beaty, R.M. Fire-climate interactions in the northern Sierra Nevada. Lake Tahoe Basin, USA, In: 3rd

	International Fire Ecology & Management Congress, 13-17 November 2006, San Diego, CA. Association for Fire Ecology. 2007. Trouet, V., Taylor, A.H., Skinner, C.N., Carleton, A.M. A tree-ring derived fire weather reconstruction and climatology for northern California and Oregon. Tree Rings in Archaeology, Climatology, and Ecology (TRACE 2007). May 3-6, Riga, Latvia. 2007. Trouet, V., Taylor, A.H., Carleton, A.M., Skinner, C.N. Multidecadal variability of fire weather and fire extent in northern California and Oregon. Seventh Symposium on Fire and Forest Meteorology, October 22-25, Bar Harbor, ME. American Meteorological Society
Technology Transfer: Presentations to a management audience	2005. Skinner, C.N. Silviculture and forest management under a rapidly changing climate. National Silviculture Workshop. Tahoe City, CA. 2006. Skinner, C.N. Fire regimes of dryer forests in the range of the northern spotted owl. Spotted Owl Recovery Team as member of invited Science Panel. June 20-21, 2006. Portland, OR. 2006. Taylor, A.H. Should climate change affect our vegetation management practices. Region 5 (California) Fuels and Vegetation Management Conference, Reno, Nevada. 2006. Taylor, A.H. Should climate change affect our vegetation and fire management practices. National Advanced Fire and Resources Institute, Tucson Arizona, Keynote Address Course Rx510 Advanced Fire Effects. 2006. Taylor A.H. How can vegetation managers respond to projected climate change and increased fire activity in California, USDA Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe, CA 2007. Skinner, C.N. *Lessons from fire history: developing landscape strategies for fire and resource management.* To: Shasta-Trinity NF Leadership Team Monthly Meeting. Mt. Shasta, CA. July 19, 2007.

Proposed	***Accomplished/Status***
Technology Transfer – Reports to local managers	2006 Skinner, C.N. Mendocino NF Fire History Sites – Preliminary Information. Report on file at Mendocino National Forest Supervisor's Office, Willows, CA. 2006 Skinner, C.N. Illinois Valley Vicinity Fire History Sites – Preliminary Information. Report on file at Illinois Valley Ranger Station, Cave Junction, OR. 2006 Skinner, C.N. Sierra Pacific Industries Fire History Sites – Preliminary Information. Report on file at Sierra Pacific Industries, Inc., Anderson, CA. 2006 Skinner, C.N. Red Star Fire Area Fire History Sites – Preliminary Information. Report on file at Tahoe National Forest, Nevada City, CA. 2006 Taylor A.H. Preliminary fire history for mixed conifer forest sites on the Bass Lake Ranger District of the Sierra National Forest, Report on file Sierra National Forest, North Fork, CA 2006 Taylor A.H. Preliminary fire history for mixed conifer forest sites on the Tule River Ranger District of the Sequoia National Forest, Report on file Sequoia National Forest, Springville, CA 2006 Taylor A.H. Preliminary fire history for mixed conifer forest sites on the Hot Springs Ranger District of the Sequoia National Forest, Report on file Sequoia National Forest, Springville, CA 2006 Taylor, A.H. Preliminary fire history for Jeffrey pine-mixed conifer forest sites on the Carson Ranger District, Toiyabe National Forest. Report on file Toiyabe National Forest, Carson City, NV 2006 Taylor, A.H. Preliminary fire history for Jeffrey pine-mixed conifer forest sites on the Sierraville Ranger District, Tahoe National Forest. Report on file Tahoe National Forest, Sierraville, CA. 2007 Skinner, C.N. Ashland Watershed Fire History – Preliminary Information. Report on file Ashland Ranger District, Rogue River National Forest, Ashland, OR. 2007 Skinner, C.N. Preliminary fire history for the Adin Pass area. Report on file Modoc National Forest, Alturas, CA. 2007 Taylor, A.H. Preliminary fire history for mixed conifer forest sites on the High Sierra Ranger District Sierra National Forest, Report on file Sierra National Forest, Prather, CA

Project Locations for Paleofire Data (ordered roughly north to south). Data from two sites on the Cleveland National Forest and one site on the Rancho Cuyamuca State Park in southern California were not used in the final analysis because they had too short of a fire-scar record.

State	**Land Owner**	**Fire History Study Areas**
Oregon	Siskiyou NF	4
Oregon	Rogue River NF	2
California	Lava Beds NM*	1
California	Klamath NF	2
California	Modoc NF	2
California	Shasta-Trinity NF	6
California	Sierra Pacific Industries	2
California	Whiskeytown NRA	1
California	Lassen NF	6
California	Lassen Volcanic NP	3
California	Mendocino NF	2
California	Plumas NF	5
California	Tahoe NF	3
California	Lake Tahoe Basin MU	3
California	Blodgett Forest, U.C.	1
California/Nevada	Humboldt-Toiyabe NF	3
California	Stanislaus NF	1
California	Yosemite NP	3
California	Sierra NF	7
California	Sequoia NF	6
California	Los Padres NF	3
California	Angeles NF	3
California	San Bernardino NF	5
Baja California, Mexico	Sierra San Pedro Martir NP	2

*Data provided courtesy of Emily Heyerdahl. Citation: Miller, R.F., & E.K. Heyerdahl. In press. Fine-scale variation of historical fire regimes in sage-brush steppe and juniper woodland: an example from California, USA. *International Journal of Wildland Fire.*