Supporting Information

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SI Methods

Age Models. To account for the two discrete sediment types (gyttja and silt) in our records, we developed a method based on original work by ref. 1. We used magnetic susceptibility (MS) as a proxy for minerogenic silt content, and for each record, we estimated MS_{crit}, the threshold MS representing 100% silt content. Given MS_{crit} and a particular sample at depth d below the sediment-water interface, we calculated the proportion of silt in the sample, θ_d, as

$$\theta_d = \min\left(1, \frac{MS_d - \min(MS)}{MS_{crit} - \min(MS)}\right)$$

Then, letting x_d represent the thickness of sample d as sliced, the effective depth at depth d,

$$ED_d = \sum_{i=0}^{d} (1-\theta_d) \cdot x_d$$

represents the accumulated depth of sediment with the instantaneous minerogenic component mathematically omitted. For each record, we solved numerically for the optimal MS_{crit}, which was defined as the value that minimized the sum of squared residuals of a linear regression of ^{14}C ages on their effective depths. Lastly, to obtain the final age of each individual sample, we fit a smooth spline through a plot of ^{14}C ages against effective depths defined by the optimal MS_{crit}. Whereas the approach of ref. 1 made the assumption that the underlying sedimentation rate of nonminerogenic sediment changed only as a linear function of time, this last step allows smooth nonlinear variations, which are common in other age-depth modeling methods (2), while retaining the representation of two sediment types.

Charcoal Peak Identification. We identified peaks representing local fire events in records of charcoal accumulation rate (CHAR) following methods in ref. 2. We first interpolated all CHAR records to constant resolution. For the main analysis (i.e. to produce the centennial and millennial fire frequency curves), we used a 10-y resolution, approximating the median sample resolution of all records. We used 5-y interpolation when identifying recent fire events for validation with observational data; this change reflects the higher true resolution of the near-surface sediments and yielded better agreement with observations. After interpolating, for each record we estimated a background charcoal trend with a locally weighted regression robust to outliers (1,000-y span) (3). This background was subtracted from the raw data to obtain a series of CHAR residuals. From these residuals, we derived a temporally local threshold value at each sample age within a 1,000-y moving window centered on the sample. Within the window, we fit residual CHAR values to a two-distribution Gaussian mixture model. Because the data were residuals, one distribution always had a mean near zero and contained most of the samples. We assumed that this distribution represents random noise, and we used its 99th percentile to define the local threshold for peak detection. After all local threshold values were computed for the record, any CHAR residuals exceeding the threshold were identified as fire events. Exploratory analysis showed that only our uppermost samples were sensitive to minimum count screening (4) because of low charcoal abundance in these low-density sediments. Mean FF of recent decades agreed best with observational data (see main text, Results and Discussion) when no screening was performed, and therefore we deemed the procedure overly conservative and omitted it. Finally, we checked the robustness of peak detection in our records using a signal-to-noise index (5). Instances of unacceptable signal-to-noise index < 3.0 were extremely rare (collectively, $<0.5\%$ of all records), thus warranting high confidence in our ability to statistically separate CHAR peaks from noise.

1. Colombaroli D, Gavin DG (2010) Highly episodic fire and erosion regime over the past 2,000 y in the Siskiyou Mountains, Oregon. *Proc Natl Acad Sci USA* 107(44): 18909–18914.
2. Higuera PE, Brubaker LB, Anderson PM, Hu FS, Brown TA (2009) Vegetation mediated the impacts of postglacial climate change on fire regimes in the south-central Brooks Range, Alaska. *Ecol Monogr* 79(2):201–219.
3. Cleveland WS (1979) Robust locally weighted regression and smoothing scatterplots. *J Am Stat Assoc* 74(368):829.
4. Gavin DG, Hu FS, Lertzman K, Corbett P (2006) Weak climatic control of stand-scale fire history during the late holocene. *Ecology* 87(7):1722–1732.
5. Kelly R, Higuera PE, Barrett CM, Hu FS (2011) A signal-to-noise index to quantify the potential for peak detection in sediment–charcoal records. *Quaternary Research* 75(1):11–17.

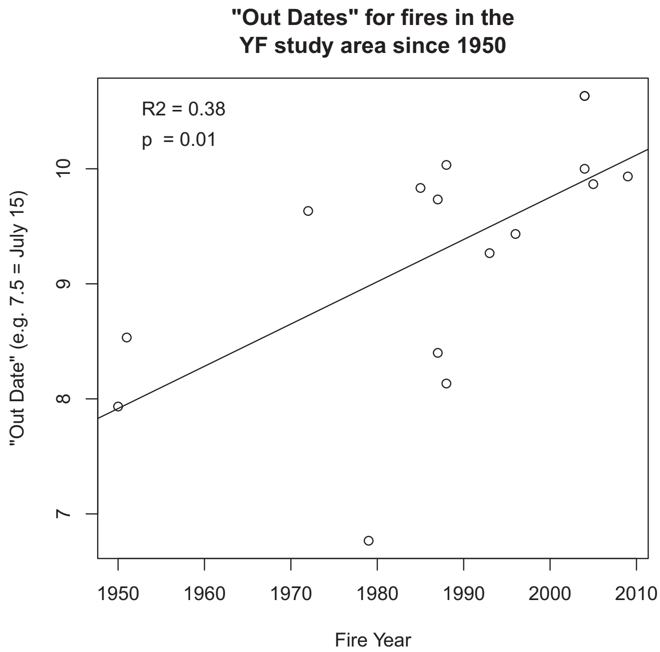

Fig. S1. Increase in late burning in the Yukon Flats (YF) study area since 1950 CE, which is illustrated by a significant trend of increasing out date over time. Out date is defined as the date that the fire was declared out as reported to the Bureau of Land Management statistics (1). Fires observed within 10 km of any study site are shown (n = 15).

1. Kasischke ES, Williams D, Barry D (2002) Analysis of the patterns of large fires in the boreal forest region of Alaska. *Int J Wildland Fire* 11:131–144.

Other Supporting Information Files

Table S1 (DOC)