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Supplementary Material

Can ash from smoldering fires increase peatland soil pH?

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Appendix A: Detailed description of sampling point selection

As described in the Methods section of the main manuscript, a 50 m-long sampling transect extended from each of the random points, with four 10 m transects perpendicular to the original main transect (Fig. S1). The main transect was always located parallel with the direction of drainage channels. The transects were walked from east to west from the starting point, while a TopCON dGPS (Topcon Corporation, Tokyo, Japan) continuously registered at 1 m intervals the occurrence of smoldering to estimate the area smoldered (Fig. S2). The smoldered surface area was drawn on paper for the 50 x 20 m area covered by the transect (Fig. S1). A new 50 x 20 m grid was used for each transect, which was generated in Microsoft Excel before field work and each grid consisted of random numbers.

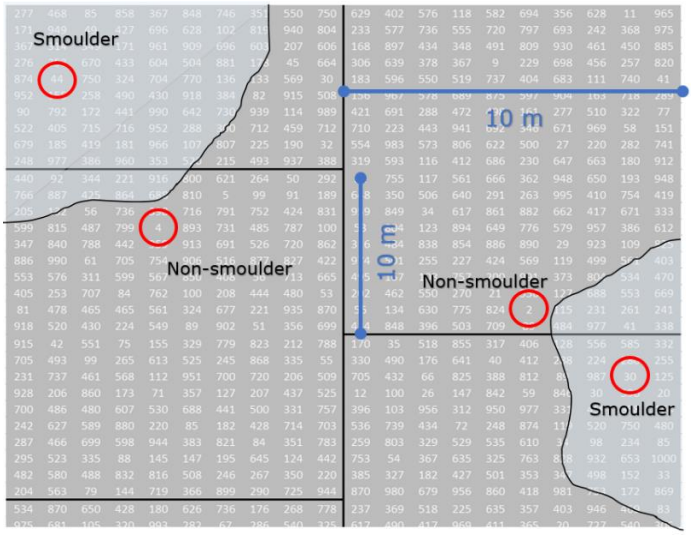

Figure S1 Schematic drawing of 50 x 20 m grid used for drawing smouldered and non-smouldered locations at each sampling transects. The light-blue patches represent smouldered areas drawn onto the grid. The red circles indicate the smallest number selected in the smoldered and non-smoldered locations. The blue lines provide a 10 m scale.

From the drawing of the visual map on the 50 x 20m grid, we located the two smallest numbers in the smouldering patch and the two smallest numbers in the non-smouldered patch. If there was no smoldering in the 50 x 20 m area of the transect, then four sampling points were randomly located in the non-smoldered area (white stars in Fig. S2). Given the complexity of smouldering patterns at our field site, some transects had 3 smouldered spots and 1 non-smouldered spot, or the other way around. Thus in short, four sampling points were always selection four places and always from the smallest number on the 50 x 20 grid.

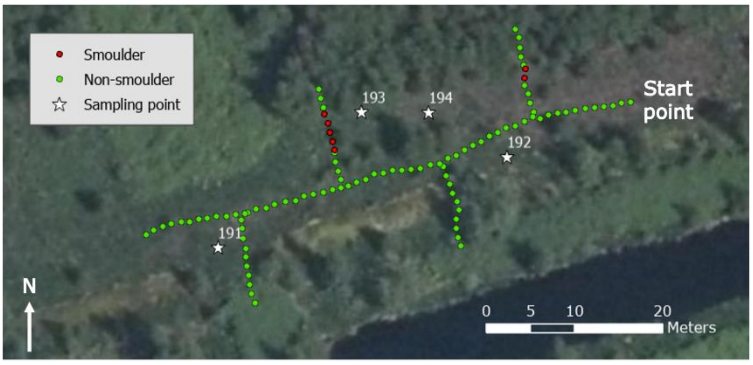

Figure S2 Example of a transect, with each dot (red or green) representing a continuously marked 1 m interval mark from the GPS while walking the transect. The red dots indicate locations where smoldering was registered and the green dots indication locations where smouldering did not occur. The white star indicates each sampling location and the number is the sample ID.

Appendix B: Spatial patterns of smouldering Explanation of environmental variables and analysis results

Introduction and explanation of analyses

We did these analyses to supplement Objective 1: assess spatial distribution of smoldering within our recently burned peatland. Using the sampling points of smoldered and non-smolder areas (described in Materials and Methods of the main text), we did two additional analyses of the occurrence of smoldering at our study site in order to establish a possible link to environmental parameters. Out of the total 82 sampling points from field work, 25 were at smoldered locations and 57 were at non-smoldered locations

In a first step, we determined if smoldering occurred at a higher elevation throughout the area, for example on ridges versus flats or at a microtopographic scale (~ ≤0.5 m). Elevation was evaluated in a paired t-test where we compared the nearest smoldered and non-smoldered sampling points within transects which had two smoldered sampling points and two smoldered sampling points. The use of DEM data in these analyses ensures that the elevation was representative of pre-fire conditions.

A second analysis was done using stepwise logistic regression to determine whether environmental conditions could predict and identify preferential conditions of the area where smoldering may be more likely to occur. The analysis consisted of the following environmental variables: the effect of soil type, soil depth, ground water, drainage density, vegetation characteristics, and topography. Summary statistics were derived for each of the environmental variables for the smoldered and non-smoldered sampling points. The differences between the points were tested for significance using a student t-test.

Detailed descriptions of all environmental variables included in the analyses and explanation of variable derivation are described here below:

- *Peat:* Soil characterization from the Dutch 1:50,000 soil survey with three general categories based on the thickness of the peat layer. Soils are characterized as Vlierveengronden with either peat (Vs) or sand (Vp) in the subsoil, Madeveen gronden (aVs) with a mineral, sandy (<10% lutum), humic topsoil but peat in the subsoil, and Veldpodzolgronden (Hn21) where peat is almost completely absent. The soil map was therefore re-classified on the basis of the peat layers with 0 for the Hn21, 1, for aVS, 2 for the Vp, and 3 for the Vs soil types
- *GWT (Groundwater class):* A separate classification was done for drainage using the Dutch classification of the so-called "grondwatertrappen" being either II, III, or VII (soil type Hn21) in the area
- *Vegetation height (veg_hght):* as determined by difference of the terrain and surface models from the AHN3
- *Drainage density (DrainDense):* calculated using a focal statistic calculating the relative coverage of water bodies (i.e., canals, bogs) around the observations points within a 100 meter radius
- *DTM*: Elevation of terrain and surface from the AHN3 (the 5 m resolution DSM/DTM of the Netherlands) in meters above sea level (masl)
- *Relative height (RelHght):* Relative height within a 15, 30, and 45 meter radius. Calculated as the difference between the elevation at a particular location and the average elevation of its surroundings
- *Topography*: Topographic differences with a 15, 30, and 45 meter radius calculated as the standard deviation of the elevation in the area
- *NDVI pre/post*: The normalized difference vegetation index derived from 20m resolution Landsat imagery from 15 April 2020 just before the fire, and from 26 June 2020 after the fire
- *Vegetation (vegetation characteristics)*: characterization as defined by LGN2019 (the Dutch 5 m resolution land cover database of 2019 reclassified as 0 no vegetation; 1 raised bog vegetation; 2: low shrubs in raised bogs; 3: high shrubs on raised bogs; and 4: forest on raised bog

Results

To determine if smoldering occurred at a higher elevation throughout the area, the elevations of smoldered and non-smoldered sampling points were compared. Results showed no significant (p=0.16) difference in elevation

of the points, nor was there a clear pattern or explanation that smoldering could occur preferentially in areas of higher elevation (Fig. S3). The analysis exploring if environmental variables could predict and identify preferential conditions of the area where smoldering may be more likely to occur showed that no significant differences exist between the non-smoldered and smoldered areas for all the predictor environmental variables (Table S1). This suggests that none of the environmental variables serve as predictors of potential locations of smoldering at our field site.

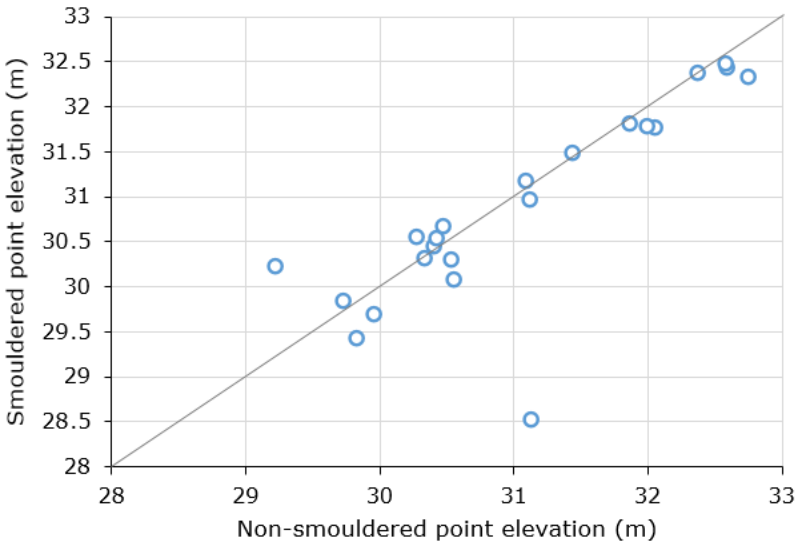

Figure S3 A comparison of the elevation of smoldered sampling points versus non-smoldered sampling points. The 1:1 line indicates the threshold at which smoldering would occur preferentially at a certain location. For example, if a majority of smoldering occurred at a higher elevation, then the blue points would be above the black 1:1 line.

Table S1 Differences in environmental variables at the Deurnese Peel, comparing smouldered and non-smouldering sampling sites. Results indicate the lack of correlation and ability of these environmental variables to predict occurrence of smouldering.

Significance at p≤0.05

Variable name	**Non-smoldered**		**Smoldered**		**t-test**
	Average	*St. dev*	*Average*	*St. dev*	**p-value**
Peat	3.32	0.81	3.46	0.86	0.48
GWT	3.02	0.45	2.92	0.27	0.32
Veg_hght	0.31	1.12	0.42	1.14	0.66
DrainDens	0.08	0.07	0.08	0.08	0.98
DTM	30.58	0.86	30.99	1.01	0.06
RelHght	0.00	0.08	0.01	0.05	0.41
Topography	0.08	0.08	0.11	0.14	0.22
NDVI pre	0.19	0.05	0.18	0.05	0.36
NDVI post	-0.12	0.07	-0.12	0.07	0.91
Vegetation	1.16	0.68	1.23	0.82	0.69

Appendix C: Maps of pH of ash and pH of soil

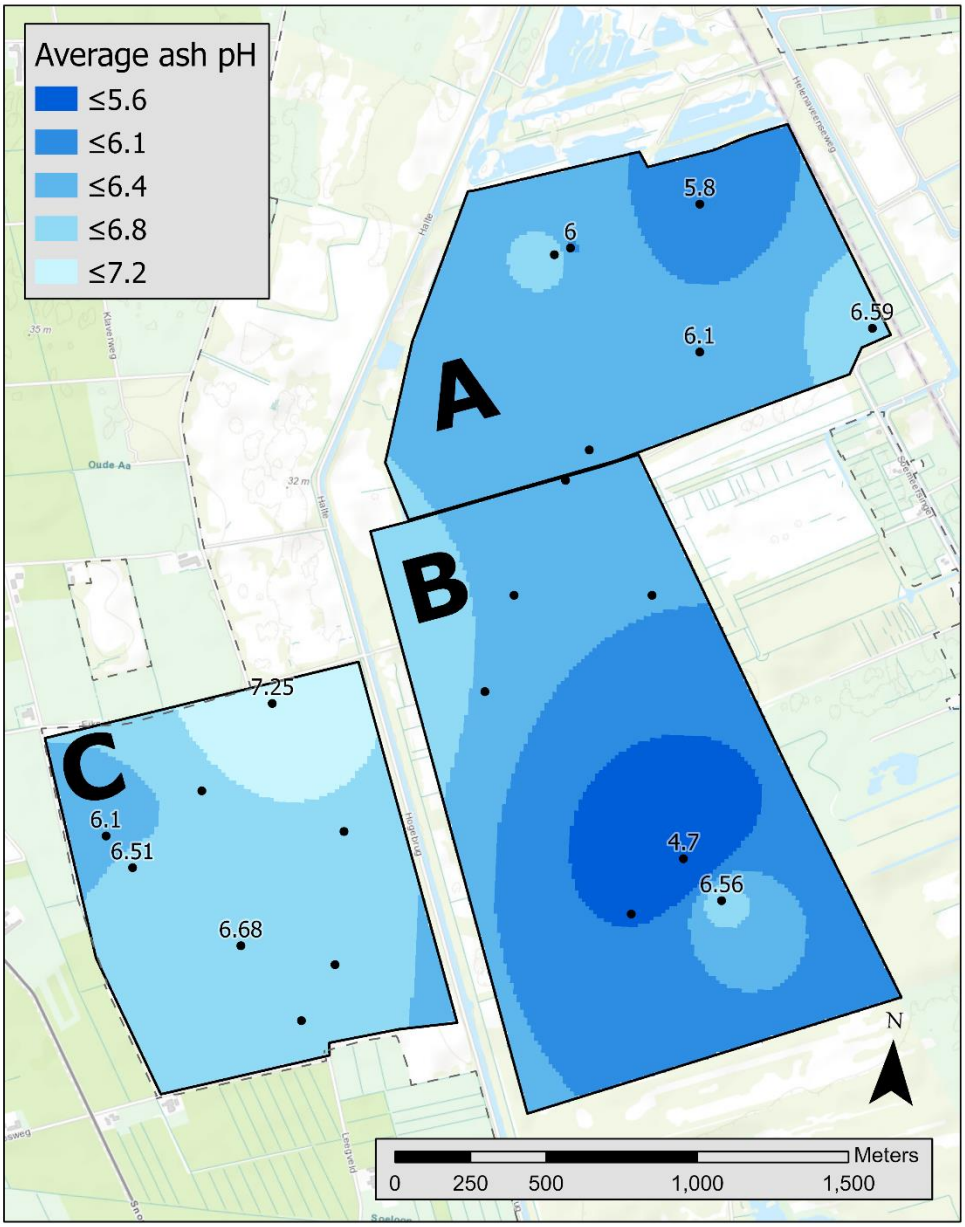

Figure S4 Aged ash pH averaged for each transect. Black circles are each transect. The number next to the black dot represents the average measured pH value at the transect. If there is not a number at a black dot, that means that ash was not sampled. Lighter blue indicates a higher (more alkaline) pH and darker blue indicates a lower (acidic) pH.

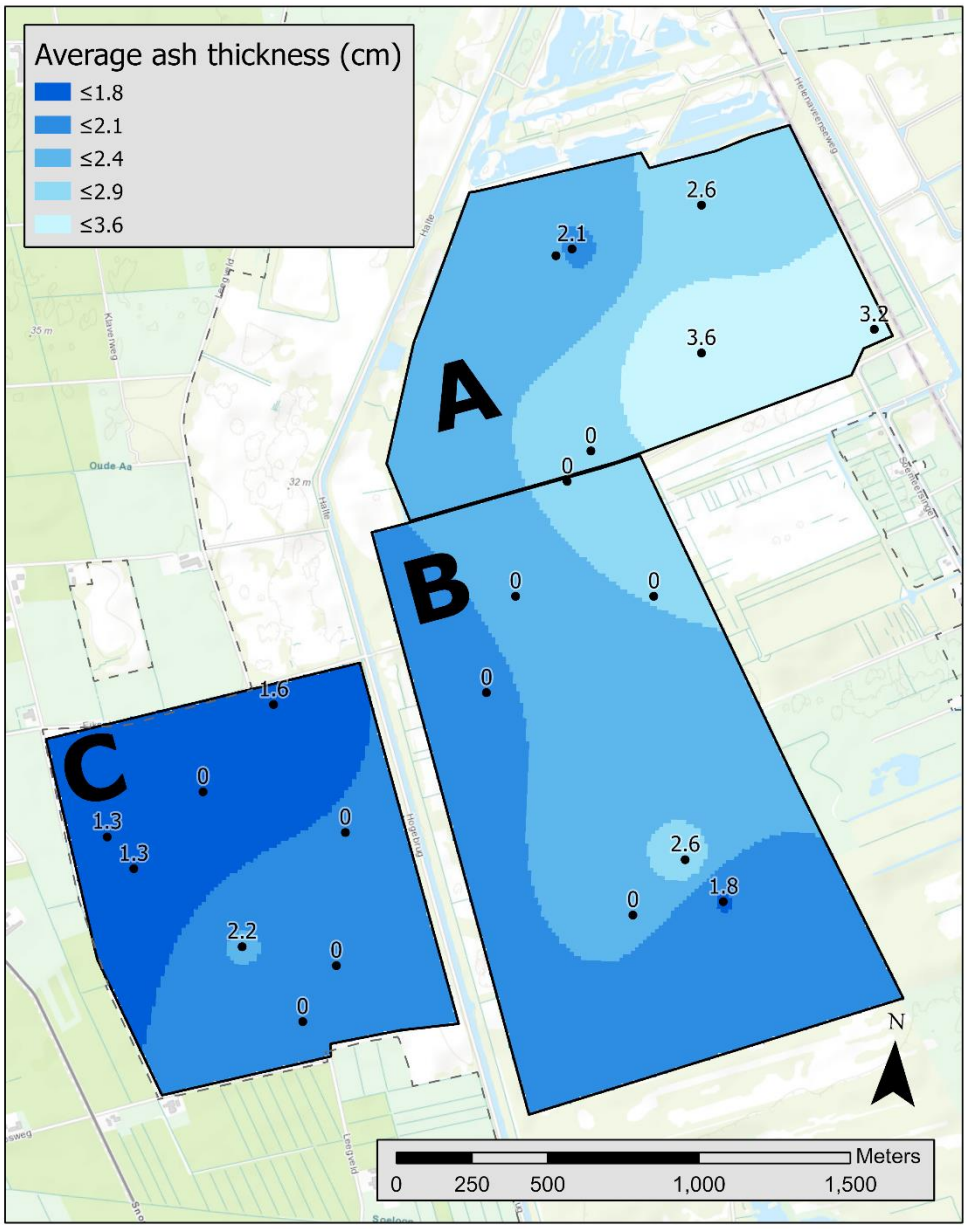

Figure S5 Average ash thickness measured at each transect. Black circles are each transect. The number next to the black dot represents the average measured ash thickness at the transect. If there is not a number at a black dot, that means that ash was not sampled. Lighter blue indicates a thicker average ash layer and darker blue indicates a thinner average ash layer

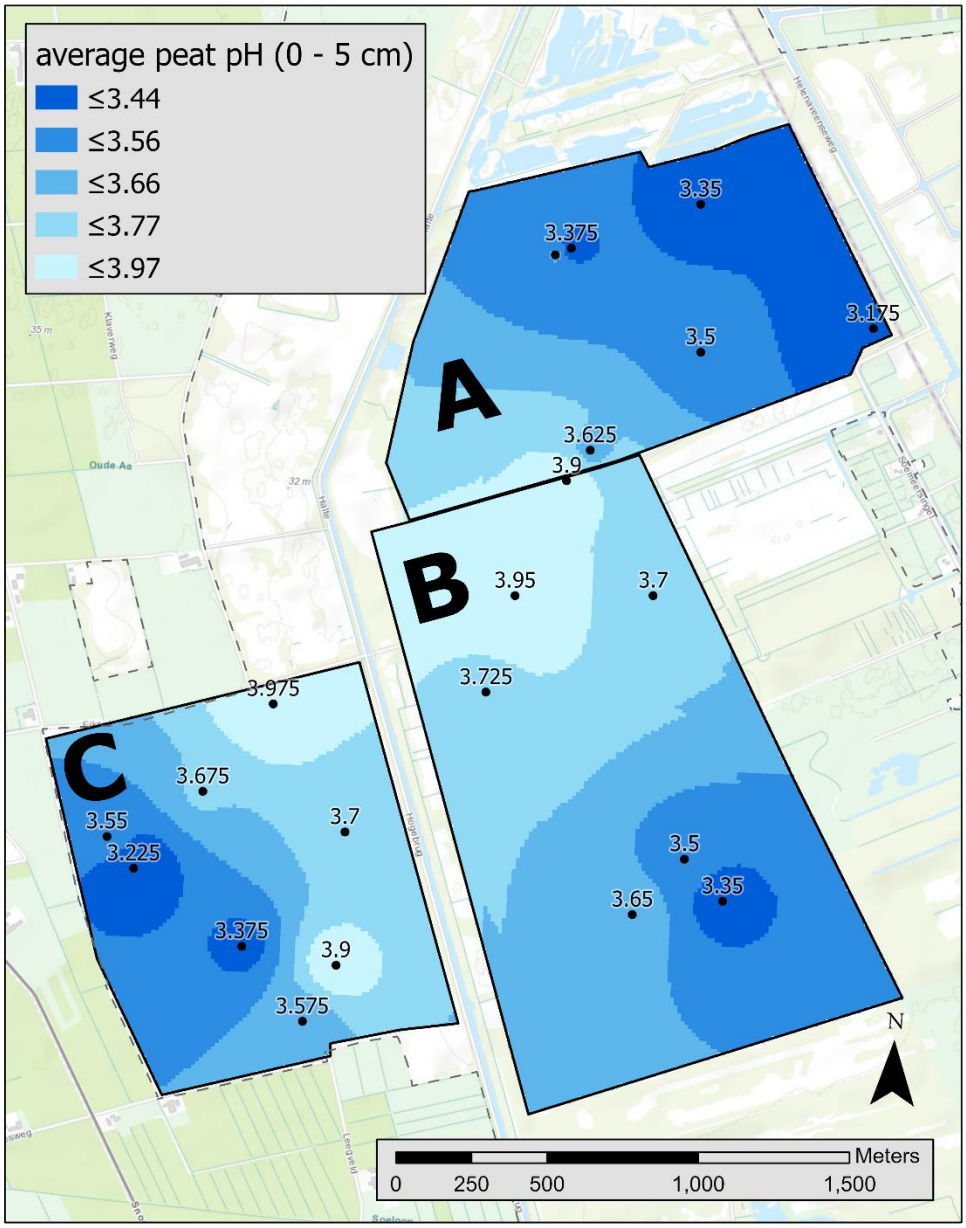

Figure S6 All topsoil (0-5cm) pH values averaged for each transect. Black circles are each transect. The number next to the black dot represents the average soil pH at each transect. Lighter blue indicates a higher (more alkaline) pH and darker blue indicates a lower (acidic) pH.

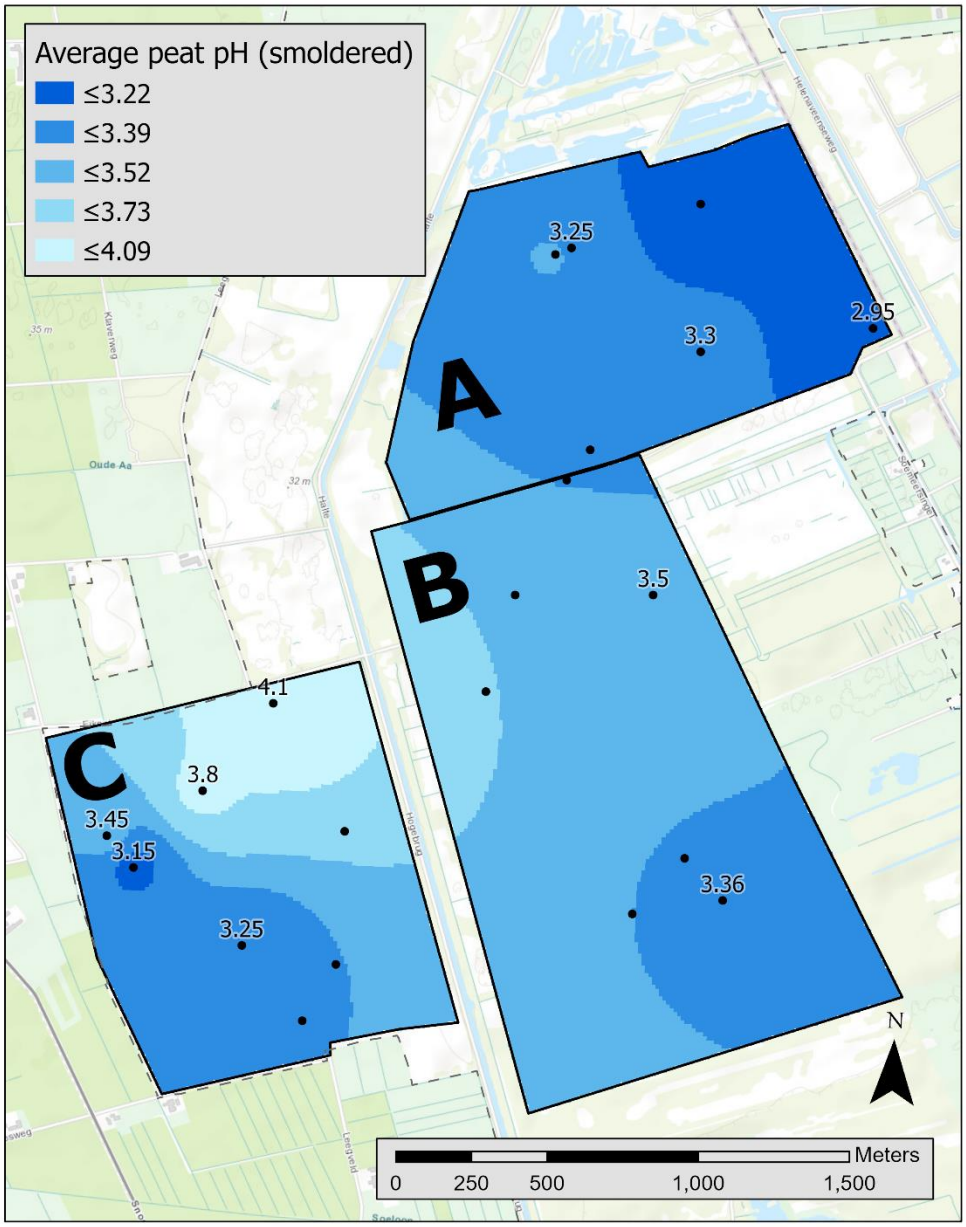

Figure S7 All topsoil (0-5cm) pH values at sampling locations which were smoldered, averaged for each transect. Black circles are each transect. The number next to the black dot represents the average soil pH at each transect. Lighter blue indicates a higher (more alkaline) pH and darker blue indicates a lower (acidic) pH.

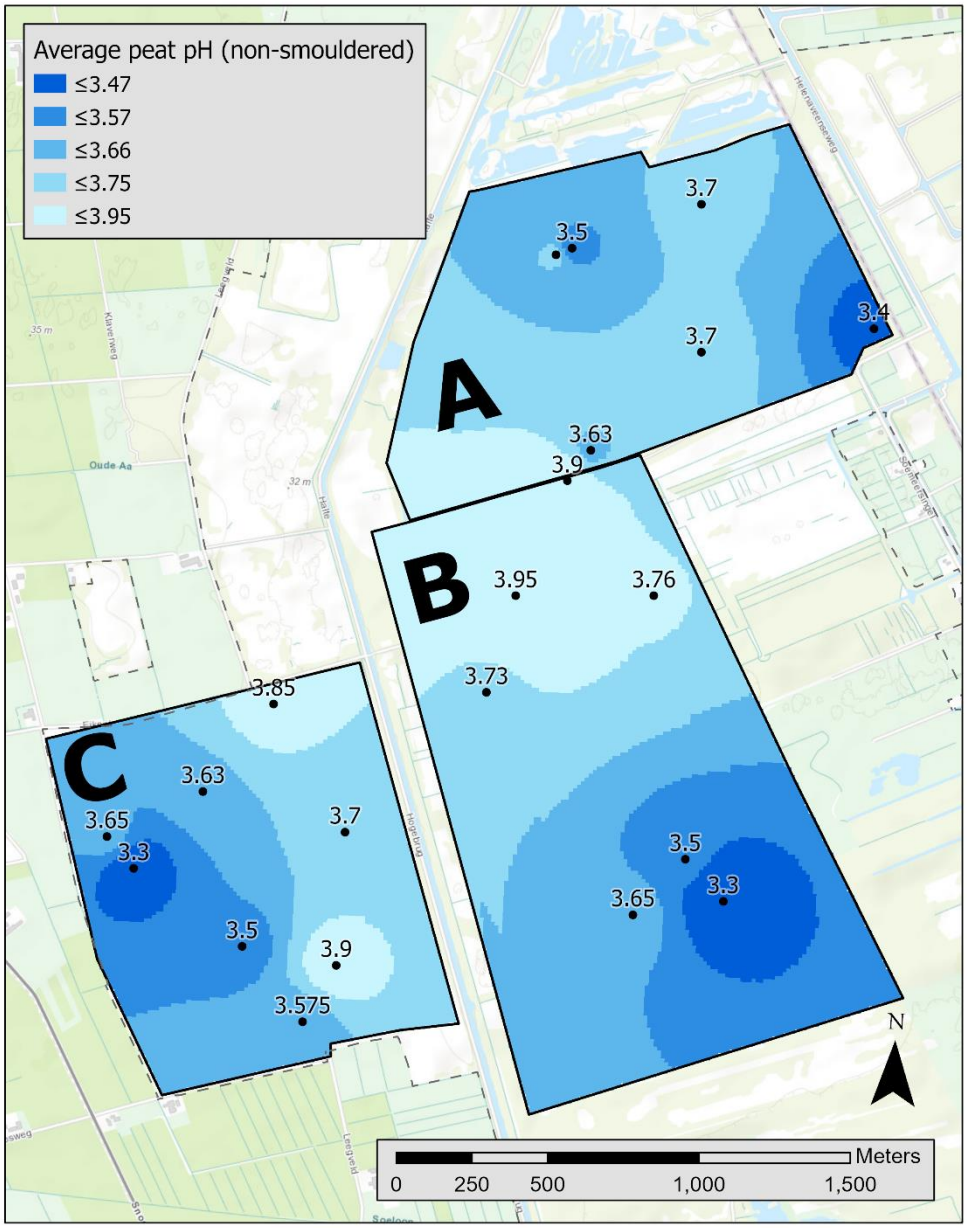

Figure S8 All topsoil (0-5cm) pH values at sampling locations where smoldering did not occur, averaged for each transect. Black circles are each transect. The number next to the black dot represents the average soil pH at each transect. Lighter blue indicates a higher (more alkaline) pH and darker blue indicates a lower (acidic) pH.