Wind farms occupy fire-prone terrain but show no evidence of targeting burnt land: a multi-scale, time-ordered analysis for Greece

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Abstract

A recurring claim in Greek public discourse holds that wildfires are set to clear land for wind farms, so that turbines end up on burnt ground. We test this with a design built to avoid the base-rate fallacy of simple overlap statistics, comparing the operational Greek wind fleet against wind-viable land with a use-availability case-control model and a time-ordered survival model, on a scale ladder from the parcel to 5 km. At the parcel scale there is no association, and thus no site-level targeting. A landscape-scale association (2 to 5 km) appears when administrative licences are weighted equally, at an odds ratio near 1.6, and near 1.4 after a fuel covariate. It is an artifact of the unit: it is absent for individual turbines, and absent when turbines are grouped into physical clusters rather than by licence at every grouping distance from 300 m to 3 km, appearing only for the administrative licence, whose boundaries subdivide interleaved developments in shared fire-prone terrain. Placing each fire at its satellite-detected ignition rather than its extent, turbines are no nearer to ignitions than random wind-viable land, at every unit. The time-ordered test is inconclusive, and the median fire-to-installation gap is 6 to 7 years. The evidence supports neither deliberate burning to build nor preferential siting on burnt land: wind farms occupy fire-prone terrain because wind and fire coincide on the same dry, exposed uplands.

Keywords: wind energy; wildfire; land use; use-availability; survival analysis; Greece

Highlights

- There is no evidence that Greek wind turbines are preferentially sited on burnt land, or near where fires ignite, at the parcel, turbine, or physical-development scale.
- A landscape-scale association appears only when administrative licences are counted as units; it vanishes when the same turbines are grouped physically.
- Wind farms occupy fire-prone terrain because wind and fire share the same dry, exposed uplands, not because burnt land is targeted.

1. Introduction

The rapid expansion of onshore wind energy across fire-prone Mediterranean landscapes has been accompanied, in Greece, by a persistent public accusation: that wildfires are deliberately set to clear forest which would otherwise block development, so that wind turbines are subsequently installed on the burnt land. The claim recurs in Greek media, social media, and local opposition to specific projects, and it matters beyond Greece because similar suspicions attach to renewable-energy siting in many fire-prone regions. If the claim were true, it would imply that turbine locations coincide with previously burnt ground at a rate above what siting on wind grounds alone would produce, and that fire tends to precede installation in a way consistent with intent.

Testing such a claim rigorously is harder than it first appears, and the intuitive tests mislead in two distinct ways. First, turbines occupy very little ground, so any statistic of the form ”turbine footprint as a fraction of burnt area” is tiny by construction and says nothing about preference; a vanishing ratio is fully compatible with strong selection, and a large ratio would be impossible regardless of behaviour. Second, and more fundamentally, the relevant comparison is not against all land, or against all burnt area, but against comparable wind-viable land. Greece burns extensively every year, and wind development concentrates on exposed ridgelines that are themselves dry, wind-swept, and fire-prone. A raw spatial overlap between turbines and burnt areas is therefore expected even under entirely innocent siting. Establishing preference requires a base rate defined on the land where turbines could plausibly be placed, and establishing the causal direction implied by the accusation requires ordering fire against installation in time.

Asking whether a set of chosen locations is drawn preferentially from an available landscape is the use-availability problem of habitat and resource-selection analysis in ecology (Johnson, 1980; Manly et al., 2002; Boyce et al., 2002), in which "used" points are contrasted with a random sample of "available" background under covariate adjustment. Framing that contrast as cases against controls sampled from an eligible universe is the logic of spatial epidemiology (Elliott & Wartenberg, 2004). Separating genuine siting preference from landscape confounding, finally, is a recurring difficulty in studies of where energy and other infrastructure is built (Diffendorfer & Compton, 2014). The methods deployed here are therefore not specific to Greece; they transfer to any contested siting claim for which a defensible set of available locations and a credible time ordering can be constructed.

The only prior public analysis of this specific Greek claim that we are aware of is a conference poster by the Hellenic Wind Energy Association (Vlamakis et al., 2025), later expanded into a detailed quantitative report (Hellenic Wind Energy Association, 2025). It reports that wind farms occupy at most 0.07% of legally reforestable land, and that turbines installed after a fire cover 0.03% of the area burnt over the period 2008 to 2024, and it concludes that there is no correlation. Those figures are footprint-over-area ratios, small by construction, computed over reforestable or burnt land rather than over wind-viable land, and they carry no inferential test of preference or of time ordering. They can motivate the question but cannot resolve it. As we show, a base-rate analysis both refines their conclusion and confirms it: no preferential siting on burnt land survives once the unit of analysis is defined physically rather than administratively.

Our central result is a qualified null. We find no evidence of parcel-level targeting and no evidence of deliberate burning to build. A landscape-scale association does appear at one unit of analysis, the administrative licence, but we show it to be an artifact of that unit: it is absent at the turbine scale and at every physical grouping of turbines, and it reflects the way interleaved developments in shared fire-prone terrain are subdivided into separate licences. The paper's contribution is thus twofold: a substantive, evidence-based answer to a charged public question about Greek wind energy, and a methodological demonstration that the answer depends sharply on the unit of analysis, the spatial scale, the completeness of the landscape controls, and in particular on whether the unit is physical or administrative.

2. Study area and data

The study covers the whole of Greece, a country with strong onshore wind resources on its mainland ridges and Aegean islands and with one of the highest wildfire burdens in the European Union. Wind development and wildfire both concentrate in dry, elevated, sparsely built terrain, which is precisely why a naive spatial overlap is uninformative and a base-rate design is required. Greece experiences hundreds of vegetation fires each year, and its largest seasons burn well over one hundred thousand hectares, with the burnt area concentrated in the same dry summers and exposed upland terrain that make ridgelines attractive for wind development. Onshore wind capacity has grown rapidly over the study period as part of national decarbonisation targets, and much of that growth has occurred on precisely the sparsely populated highland sites where fire is also most frequent. This shared geography is the source of the confounding that the present design is built to address, and it is the reason the question cannot be settled by inspecting a map of overlaps. Independent quantification confirms that Greek wind development concentrates on remote, higher-elevation natural terrain, with access roads dominating its land take (Kati et al., 2023), which is the same upland geography in which fire is most frequent.

The unit of the wind fleet is the operational Greek Wind Power Station, equivalently a licensed wind farm, listed in the production-licence registry of the Regulatory Authority for Waste, Energy and Water (RAAEY, 2024), restricted to stations holding an operating licence (437 stations). Turbine geometry is taken from OpenStreetMap (2024), which for Greek wind turbines matches the industry count closely; of 2,995 mapped turbines, 2,958 are assigned to a station within 5 km and 37 are orphans. The 437 operational stations are the subset, of a larger fleet of 508 licensed stations reported by industry, that carry an operating rather than merely a production or installation licence; the remainder are excluded because they are not yet operational or lack the licence status from which a commissioning date can be derived. The 37 orphan turbines, more than 5 km from any station, are excluded from all farm-level analyses and never enter any of the three tests. Commissioning dates were resolved from public administrative acts to exact dates (from the Diavgeia transparency portal; 102 stations), to bounded intervals (113 stations), or to broader brackets from grid-operator records (117 stations); 105 stations remained unresolved, most of them either commissioned before 2008 or located on non-interconnected islands.

Fire perimeters come from the Copernicus European Forest Fire Information System (EFFIS) MODIS burnt-area product (European Forest Fire Information System, 2024), which maps fires above a nominal 30 ha threshold as dated polygons. The public layer covers approximately 2016 onward; perimeters for 2010 to 2015 were obtained through the EFFIS data-request service within the same product family. The merged 2010 to 2024 dataset comprises 1,644 perimeters totalling 607,005 ha, consistent with the 615,363 ha reported for 2008 to 2024 by the Hellenic Wind Energy Association (2025) once the two additional early years are allowed for.

Covariates are drawn from open products. Mean wind speed at 100 m is from the Global Wind Atlas (Global Wind Atlas, 2023); slope and aspect are derived from the Copernicus GLO-90 digital elevation model (European Space Agency & Airbus, 2022); land cover, including the fire-prone fuel classes used later, is from CORINE 2018 (European Environment Agency, 2019a); and protected status is from the Natura 2000 network (European Environment Agency, 2019b). All raster operations are performed on a common 100 m grid in the ETRS89 Lambert Azimuthal Equal-Area projection (EPSG:3035). Finally, to distinguish where fires ignited from the extent they eventually reached, we use NASA FIRMS satellite active-fire detections (NASA FIRMS, 2024), combining the MODIS and the VIIRS Suomi-NPP standard-processing archives, 308,618 detections over Greece for 2010 to 2024; the earliest detection inside each burnt-area perimeter serves as an approximate ignition point and time (Section 3). Table 1 summarises the sources and their roles.

Table 1. Data sources and their roles in the analysis.

Layer	Product	Native resolution	Role
Turbines	RAAEY licences and OpenStreetMap	point	cases and events
Fire	EFFIS MODIS burnt areas, 2010 to 2024	~250 m	exposure
Wind	Global Wind Atlas, 100 m mean speed	~250 m	universe gate and covariate
Elevation	Copernicus GLO-90	~90 m	slope and aspect covariates
Land cover	CORINE 2018	100 m	exclusions and fuel covariate
Protected areas	Natura 2000	vector	covariate

Layer	Product	Native resolution	Role
Active fire	NASA FIRMS MODIS + VIIRS detections, 2010 to 2024	~375 m to 1 km	ignition points

Source: compiled by the author.

3. Methods

Our design combines three complementary tests, each addressing a different facet of the accusation and each evaluated against the same eligible universe of wind-viable land. Test A asks, descriptively, whether fires tend to predate installation; it frames the ordering question but has no base rate. Test B asks whether wind farms are associated with burnt land more strongly than comparable wind-viable land would predict, using a use-availability case-control model; it is the core test of spatial preference. Test C asks whether a prior fire raises the subsequent probability of installation on eligible land, using a time-varying survival model in which fire enters as a time-dependent covariate; it is the core test of temporal direction. No single test is decisive alone: a spatial association without a time ordering points to shared static geography, whereas a genuine burn-to-build process should leave both a spatial signal and a positive, temporally ordered one. We therefore report all three across a common scale ladder and interrogate each for landscape confounding. The remainder of this section defines the eligible universe and then each test in turn.

3.1 The eligible universe

The eligible universe is the set of wind-viable land cells that serves as the denominator for all base-rate comparisons; it is the ”available” set against which used locations are contrasted. Both defining thresholds are calibrated to the existing fleet. The wind floor is set to the fifth percentile of Global Wind Atlas speed at existing turbines, 5.96 m/s, close to the conventional 6.0 m/s cut-off, and the slope ceiling is set to the ninety-fifth percentile of slope at existing turbines, 16.07 degrees. We further exclude open water, glaciers, and dense artificial surfaces (CORINE classes 511 to 523, 335, 111, 112, 123, 124, and 141), and we mask to Greek land defined as the intersection of Global Wind Atlas validity and CORINE data presence. The resulting primary universe covers 17,361 km2, and 89.5% of mapped turbines (2,680 of 2,995) fall inside it, as expected under fleet calibration. Calibrating the universe to the fleet introduces a mild circularity, since cases help define the available set; we probe its consequences directly with a wind-by-slope threshold grid described below. Figure 1 shows the study area, the eligible universe, the burnt-area perimeters, and the turbine locations.

3.2 Test A: temporal precedence

For each station we form the convex hull of its turbines and buffer it at radii from 500 m to 5 km, then compare the dates of intersecting fires to the station's commissioning window, classifying each station as having a fire that predates installation, that is ambiguous, that postdates installation, or none. Test A is purely descriptive and has no base rate; it is reported to show why raw counts, which grow with catchment size for every category simultaneously, cannot settle the question.

3.3 Test B: use-availability case-control

Test B asks whether wind sites fall near burnt land more often than comparable wind-viable land does. It contrasts cases, the wind sites, with controls, a random sample of the eligible uni-

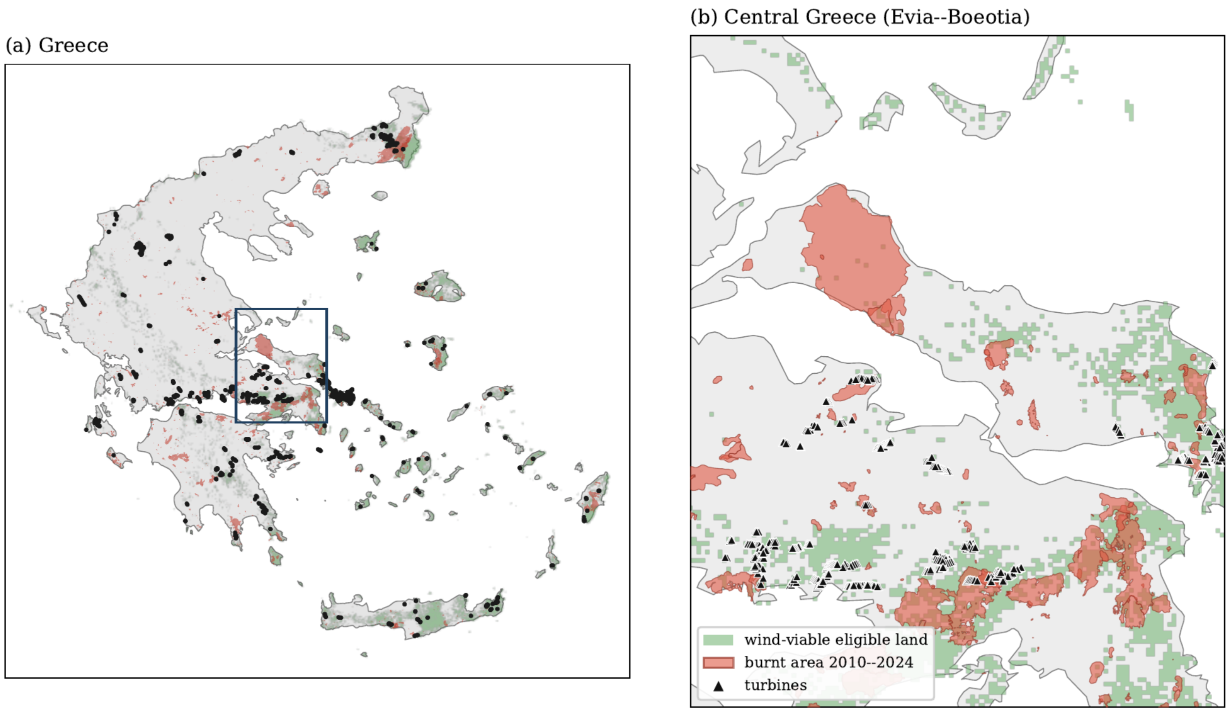
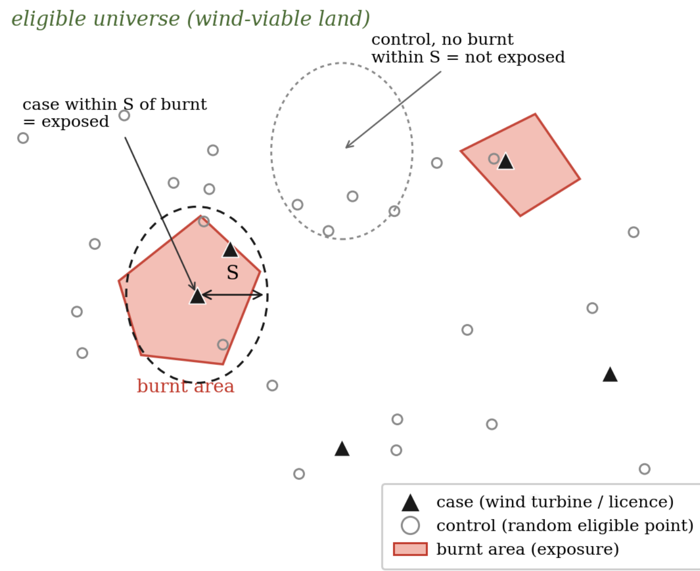


Figure 1. Study area. (a) Greece: national territory, wind-viable eligible land (green), burnt-area perimeters for 2010 to 2024 (red), and operational turbines (dark points); the box marks the inset. (b) Central Greece (Evia and Boeotia), showing turbines, burns, and eligible land within fire-prone terrain.

verse, and asks whether being burnt-adjacent separates the two once landscape is accounted for (Figure 2). Controls are 30,000 cells drawn uniformly at random, without replacement, from the eligible universe, one point per cell; estimates are stable to this count.



Compare the burnt-exposure of cases vs controls by logistic regression, adjusting for wind, slope, elevation, aspect, protection, and fuel.

Figure 2. Test B as a use-availability case-control design. Cases (wind sites) are contrasted with controls drawn at random from the wind-viable eligible universe. A point is exposed if a burnt area lies within radius S of it. Logistic regression then asks whether burnt-adjacency distinguishes cases from controls once wind, slope, elevation, aspect, protection, and fuel are held constant.

The exposure is being burnt within the observation window: a case or control point lies within a radius S of any 2010 to 2024 perimeter. Each specification is a logistic regression of case status on the burnt indicator plus wind speed, slope, elevation, aspect (as northness and eastness), and Natura status, with continuous covariates standardised.

We report two case definitions, because they answer different questions. In the turbine unit, cases are the 2,644 assigned turbines inside the universe (orphans excluded), with standard errors clustered by station; because it weights each project by its turbine count, this unit estimates the chance that an installed turbine lies near burnt land, and it is dominated by large developments. In the licence unit, cases are one representative point per RAAEY licence, the centroid of the convex hull of its turbines, weighting each project equally; this estimates the chance that a project is sited near burnt land.

Test B counts any overlap within the window, including fires that postdate installation, so the temporal direction is left to Test C. As an alternative exposure aimed at fire origin rather than extent, we replace the perimeter with an ignition point, the earliest FIRMS active-fire detection within 1 km of the perimeter, and repeat Test B at every unit.

3.4 Test C: time-varying survival

We follow eligible locations from 1 January 2010. The event is installation, meaning farm commissioning between 2010 and 2024 for stations with a resolvable date, and the risk set is a random sample of the eligible universe, administratively censored at 31 December 2024.

All units enter at the time origin; there is no delayed entry or left-truncation. Stations installed before 2010, and stations with unresolved dates, are prevalent rather than incident and are excluded from the event set. The number of incident events is 165 when events are restricted to the eligible universe, our primary specification; when all resolvable farms are admitted, a sensitivity analysis, the number is 229. Fire enters as a time-dependent covariate that switches from zero to one at the fire date, so that only fires preceding a given time contribute to the hazard and post-installation fires never count. Events and controls are treated symmetrically as points sharing the same catchment. Following standard practice for the Cox model (Cox, 1972), we test the proportional-hazards assumption for the burnt effect using an interaction between the burnt indicator and follow-up time. Test C is also re-estimated with fire entering at its ignition point and time rather than its perimeter, so that the temporal test concerns fire origins.

3.5 Scale ladder, fuel covariate, and robustness

Tests B and C are evaluated at radii from the point to 5 km, with the same radius applied to cases and controls so that the base rate moves with scale. To separate landscape fire-proneness from targeting, we add a scale-matched fuel covariate: the fraction of fire-prone natural fuel within the catchment, computed from CORINE forest, shrub, sclerophyllous vegetation, natural grassland, transitional woodland-shrub, and sparsely vegetated classes, and computed independently of where fire actually occurred. For the licence-level association we replace seed-to-seed anecdote with a permutation test using 1,000 label permutations, and with a wind-by-slope threshold grid that rebuilds the eligible universe under nine combinations of wind floor and slope ceiling. In the gap analysis a short gap is defined as installation within three years of the fire.

4. Results

4.1 Temporal precedence

Burnt-before farm counts grow with catchment size, from 17 at 500 m to 95 at 5 km, but so do fires of every other category (Table 2); by 5 km almost every farm, and almost every random point, has a fire within range. A raw count therefore cannot distinguish preference from the background fire rate, which is exactly the base-rate problem the remaining tests are designed to overcome.

Table 2. Test A, farm-level temporal precedence for 302 resolved stations; 96 unresolved stations are reported separately.

Catchment	Predates	Ambiguous	Postdates	No fire
hull + 500 m	17	9	41	235
hull + 1 km	31	12	47	212
hull + 2 km	55	19	67	161
hull + 3 km	71	21	78	132
hull + 5 km	95	28	88	91

Source: authors' analysis of EFFIS and RAAEY data.

4.2 Spatial association depends on the unit

The spatial result depends on the unit of analysis (Table 3, Figure 3). Under the turbine unit, the burnt association is null at every scale and is entirely removed by the fuel covariate. Under the licence unit, weighting each licensed project equally, a strong and significant landscape-scale association emerges: the burnt odds ratio is 1.64 at 2 km, rising to 1.69 at 5 km. Adding the fuel covariate explains about half of this but leaves a residual odds ratio of 1.40 at 2 km, 1.39 at 3 km, and 1.35 at 5 km, all statistically significant; at 1 km the fuel covariate removes it entirely. The parcel scale is null in both units. As shown below, this licence-level association does not survive a physical definition of the unit.

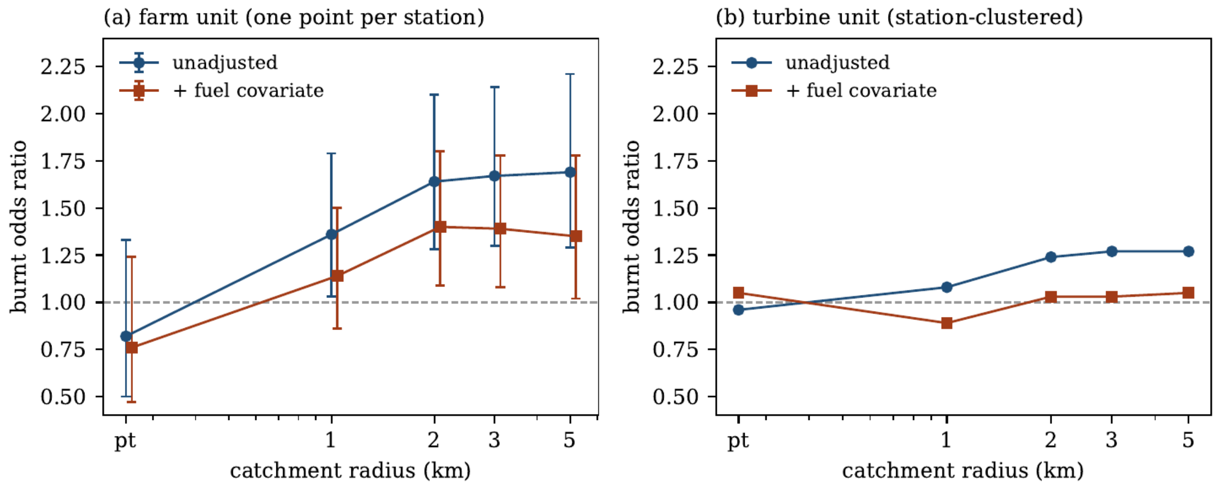


Figure 3. Test B burnt odds ratio with 95% confidence intervals, unadjusted and with the fuel covariate, across catchment radius. (a) Licence unit: a significant 2 to 5 km association with a residual near 1.4 after fuel, shown to be an artifact of the administrative unit (see Table 6). (b) Turbine unit: null and fully absorbed by fuel. The dashed line marks no effect.

Table 3. Test B burnt odds ratio with 95% confidence intervals, unadjusted and with the fuel covariate, by unit and scale.

Scale	Turbine, unadjusted	Turbine, + fuel	Licence, unadjusted	Licence, + fuel
point	0.96 (0.62–1.47)	1.05 (0.69–1.61)	0.82 (0.50–1.33)	0.76 (0.47–1.24)
1 km	1.08 (0.82–1.41)	0.89 (0.67–1.18)	1.36 (1.03–1.79)	1.14 (0.86–1.50)
2 km	1.24 (0.97–1.58)	1.03 (0.80–1.33)	1.64 (1.28–2.10)	1.40 (1.09–1.80)
3 km	1.27 (0.99–1.64)	1.03 (0.79–1.35)	1.67 (1.30–2.14)	1.39 (1.08–1.78)
5 km	1.27 (0.95–1.70)	1.05 (0.76–1.44)	1.69 (1.29–2.21)	1.35 (1.02–1.78)

Source: authors' analysis.

Within the licence unit this association is not a chance or point-selection artifact. A permutation test on the 2 km fuel-adjusted estimate, using 1,000 label permutations (seed 0), yields $p = 0.029$, placing the observed effect well outside the permutation null. It is stable across the wind-by-slope threshold grid (Table 4), where the fuel-adjusted odds ratio ranges from 1.25 to 1.39 and is significant in eight of the nine universe definitions, the exception being wind ≥ 5.5 m/s with slope ≤ 18° at $p = 0.067$ (areas and case counts in Table 5). It is also stable across the choice of representative point for each licence: the fuel-adjusted 2 km odds ratio is 1.40 for the primary hull-centroid point, 1.41 for the mean-coordinate centroid, 1.32 for the turbine nearest the centroid, and 1.30 on average (significant in 15 of 20 draws) for a randomly chosen turbine per licence.

Table 4. Licence-level Test B at 2 km, fuel-adjusted burnt odds ratio with 95% confidence intervals, across eligible-universe thresholds.

	slope ≤ 15°	slope ≤ 18°	slope ≤ 20°
wind ≥ 5.5	1.38 (1.07–1.77)	1.25 (0.98–1.59)	1.27 (1.01–1.60)
wind ≥ 6.0	1.35 (1.04–1.73)	1.35 (1.06–1.72)	1.30 (1.03–1.65)
wind ≥ 6.5	1.39 (1.07–1.80)	1.32 (1.03–1.69)	1.28 (1.01–1.63)

Source: authors' analysis.

Table 5. Eligible-universe area (km2) and number of licence cases for each threshold in Table 4.

	slope ≤ 15°	slope ≤ 18°	slope ≤ 20°
wind ≥ 5.5	21,524 (n = 295)	25,199 (n = 326)	27,291 (n = 345)
wind ≥ 6.0	15,885 (n = 281)	18,726 (n = 311)	20,344 (n = 329)
wind ≥ 6.5	11,608 (n = 265)	13,782 (n = 291)	15,023 (n = 307)

The association is, however, specific to the administrative licence as the unit. When the same turbines are grouped into physical clusters by spatial proximity, independently of licence boundaries, the fuel-adjusted 2 km association disappears at every clustering distance (Table 6): the odds ratio lies between 0.91 and 0.99 and is never significant, from 300 m clustering (1,040 clusters) to 3 km clustering (163 clusters). It is also null at the turbine unit. The signal thus appears only when the roughly 400 administrative licences are treated as independent units, and vanishes under both finer (turbine) and coarser (physical-cluster) groupings.

The most economical explanation, consistent with the interleaved and subdivided licence geometry seen in the field, is that developments in fire-prone terrain are divided into more, spatially overlapping licences, so that weighting each licence equally over-counts the shared fire-prone ground; grouping the turbines physically removes the over-counting and the association.

Table 6. Fuel-adjusted burnt odds ratio at 2 km when turbines are grouped into physical clusters by proximity (one point per cluster), compared with the administrative licence unit (represented by its mean-coordinate centroid).

Grouping	Distance	Groups	Odds ratio (95% CI)	p
Administrative licence	—	398	1.41 (1.11–1.80)	0.005
Physical cluster	300 m	1,040	0.97 (0.82–1.13)	0.68
Physical cluster	500 m	561	0.95 (0.77–1.17)	0.65
Physical cluster	1,000 m	306	0.95 (0.71–1.26)	0.71
Physical cluster	1,500 m	233	0.99 (0.71–1.37)	0.93
Physical cluster	2,000 m	199	0.95 (0.67–1.37)	0.80
Physical cluster	3,000 m	163	0.91 (0.60–1.36)	0.64

Source: authors' analysis.

4.3 Proximity to fire ignitions

The exposure used so far is the extent of each burnt area, so a location counts as near a fire even when the fire spread to it from a distant origin. Using instead the ignition point, the earliest satellite active-fire detection inside each perimeter, sharpens the test to where fires start. Ignition points were recovered for 1,590 of the 1,644 perimeters (97%). Against them the fuel-adjusted 2 km association is null at every unit (Table 7): the odds ratio is 0.91 for turbines, 1.17 for the administrative licence, and 0.94 for physical clusters, none significant. The licence figure is the telling one: the 1.41 seen against fire extent falls to a non-significant 1.17 once the fire is placed at its origin rather than its edge, so even the administrative-unit signal is a feature of where fires reach, not where they begin.

Table 7. Test B at 2 km, fuel-adjusted, against fire ignition points (earliest FIRMS detection per perimeter) versus burnt-area extent.

Unit	Near ignition point: OR (95% CI), p	Near burnt extent: OR
Turbine	0.91 (0.80–1.04), 0.16	~1.0 (null)
Administrative licence	1.17 (0.87–1.57), 0.29	1.41 (p 0.005)
Physical cluster	0.94 (0.65–1.35), 0.73	0.95 (null)

Source: authors' analysis of FIRMS and EFFIS data.

4.4 The time-ordered test is inconclusive

Treating events and controls symmetrically as points, the hazard ratio for prior burn is null when all 229 resolvable farms are admitted (2 km hazard ratio 1.12, 95% confidence interval 0.93 to 1.35, $p = 0.22$), but significant when events are restricted to the eligible universe (165 events; 2 km hazard ratio 1.32, $p = 0.007$; 3 km hazard ratio 1.25, $p = 0.017$). The fuel covariate leaves either version essentially unchanged. In the significant specification the proportional-hazards assumption is violated: the interaction between the burnt indicator and follow-up time is strong and negative ($p < 0.001$), so the effect is not constant over follow-up and the single hazard ratio is only a time-average. Because the estimate swings between null and significant across defensible design choices, and violates proportional hazards where it is positive, Test C is inconclusive on the temporal direction. Re-estimated against ignition timing rather than perimeter timing, the hazard ratio is null for both event sets, 1.04 ($p = 0.73$) for all resolvable farms and 1.10 ($p = 0.46$) in the eligible universe, so no time-ordered association with fire origins is present either.

4.5 Fire-to-installation gap

For farms that burnt before installation, the interval between fire and installation is long, with a median of 6 to 7 years, dominated by the five-to-ten-year bin and extending to 12 years (Table 8, Figure 4). That most fires fall after the production licence is a timeline artifact rather than a signal. Greek production licences were mostly issued before the fire record begins in 2010, and installation often follows the licence by more than a decade, so with roughly 9,600 forest-fire incidents reported in Greece each year (Hellenic Fire Service, 2024) an incidental fire somewhere in that long window is close to certain. Consistent with this, the genuinely suspicious profile, a short gap combined with a fire after the licence, appears in only 3 to 11 farms, no more than chance would produce. The EFFIS perimeters used here map fires above about 30 ha and number roughly 110 per year, so the raw ordering of licence and fire dates carries little information.

Table 8. Fire-to-installation gap and licence ordering for burnt-before farms; a short gap is installation within three years of the fire.

Catchment	n	Median gap (yr)	Fire after / before licence	Short gap and post-licence
hull	12	6.8	11 / 0	3
500 m	20	6.8	19 / 0	4
1 km	35	6.1	30 / 2	11

Source: authors' analysis.

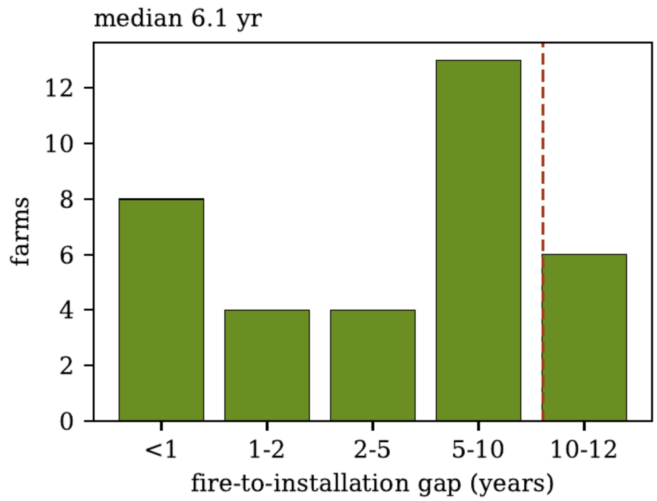


Figure 4. Fire-to-installation gap for burnt-before farms (1 km catchment, n = 35); median 6.1 years.

5. Discussion

The parcel scale is null in every test, so there is no evidence that specific burnt parcels were selected for specific turbines. What survives is a landscape-scale spatial association, and its character can now be described precisely.

5.1 Why the unit of analysis matters, and why the association is not geographic

The apparent landscape-scale association depends entirely on how the unit is defined, and tracing that dependence shows the association is not a geographic preference. Two facts point the same way. First, weighting by turbine count removes it: larger developments are less fire-adjacent, with the share of licences having a fire within 2 km falling from 0.50 in the smallest size tercile to 0.34 in the largest, and burnt-proximity declining at an odds ratio of 0.57 per tenfold increase in turbine count ($p = 0.056$), so the turbine unit, dominated by these large developments, is null. Second, and decisively, grouping turbines physically rather than administratively also removes it: at every clustering distance from 300 m to 3 km the fuel-adjusted odds ratio is close to one and non-significant.

The association survives only at the level of the roughly 400 RAAEY licences, where it is robust to inference, to the universe definition, and to how each licence is represented, yet it is bracketed on both sides by null results at finer and coarser physical groupings. This is the pattern expected if developments in fire-prone terrain are administratively subdivided into more, spatially interleaved licences than developments elsewhere: counting each licence equally then over-represents the shared fire-prone ground, an over-representation that physical grouping

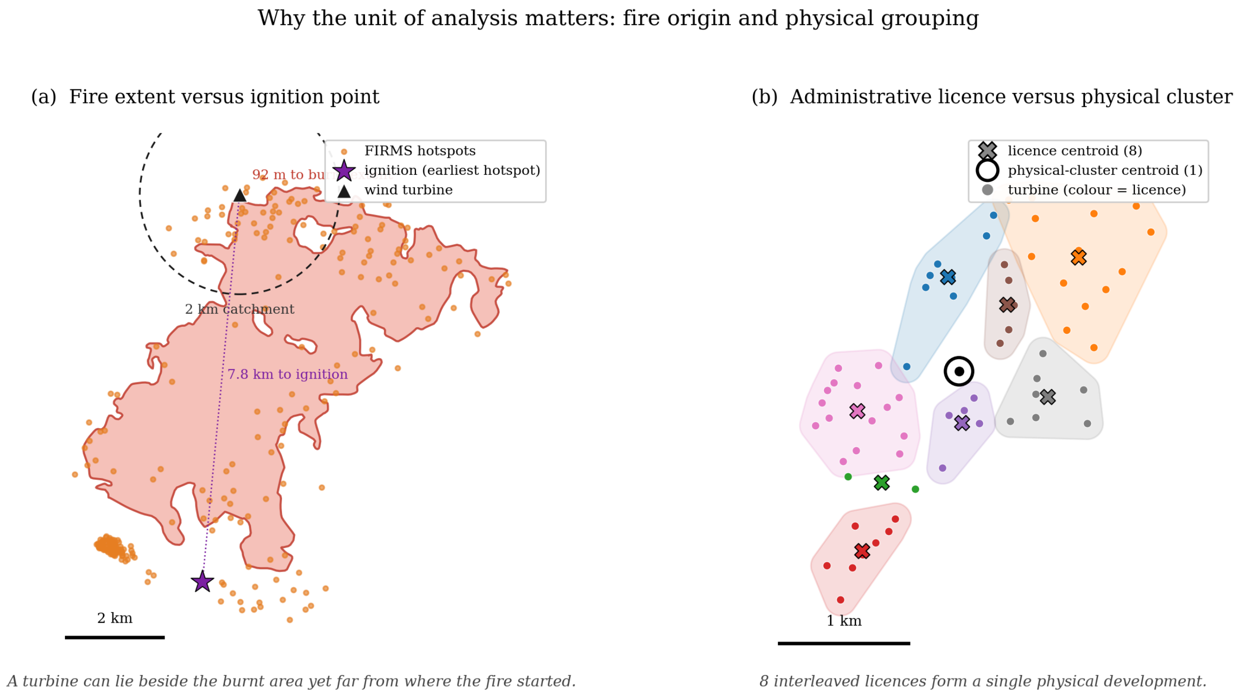


Figure 5. Why the unit of analysis matters, on real data. (a) Fire extent versus ignition point: a burnt-area perimeter with its FIRMS hotspots, the earliest marked as the ignition; the nearest turbine lies 92 m from the burnt extent but 7.8 km from the ignition, so under perimeter exposure it counts as near the fire yet is far from where the fire began. (b) Administrative licence versus physical cluster: eight interleaved RAAEY licences (turbines coloured by licence, centroids marked X) occupy one physical development (single ringed centroid), so counting each licence equally over-represents the shared fire-prone terrain, an over-counting that physical grouping removes.

dissolves (Figure 5b). A licence is an administrative construct, not a siting decision made once per contiguous project, so a signal that exists only at that unit is not evidence of geographic preference.

5.2 What remains, and what does not

Once the administrative artifact is set aside, no positive signal of preferential siting remains at any physically meaningful unit. What is left is unsurprising and not in dispute: wind farms occupy fire-prone terrain. They do so because wind resources and fire risk coincide on the same dry, exposed, sparsely built uplands, not because burnt ground is sought out. Our measured covariates, wind, slope, elevation, aspect, protected status, and fuel composition, capture much of that shared geography, and the remainder is administrative rather than behavioural. For the specific accusation, that fires are set in order to build, the evidence is unsupportive on every axis: the parcel scale is null, the turbine and physical-cluster scales are null, the time-ordered hazard is fragile and non-proportional where positive, and the fire-to-installation gaps are long. A mechanism in which fires were intentionally set to facilitate construction would produce short, consistent fire-to-installation intervals and a stable positive temporal association; we observe none of these. Placing each fire at its ignition point rather than its extent removes even the administrative-unit signal (Section 4.3) and leaves the time-ordered test null, so turbines are no nearer to where fires start than to random wind-viable land (Figure 5a).

5.3 Relation to prior work

Our conclusion converges with, and strengthens the basis for, earlier analyses that found no correlation between wind farms and burnt land (Vlamakis et al., 2025; Hellenic Wind Energy Association, 2025), while grounding it in a comparison against the land where turbines could actually be placed, which the earlier footprint percentages did not provide. A recent quantitative analysis of the same question also reports, from fire-service ignition records for 2020 to 2024, no case of a wind turbine installed inside a burnt area after the fire started (Hellenic Wind Energy Association, 2025); our independent satellite ignition analysis reaches the same null across the full 2010 to 2024 period.

Several legal and practical considerations raised in the wider debate point the same way: that legislation permits wind development on forest land irrespective of fire history; that permitting becomes more difficult, not easier, after a fire; that burnt ground confers no construction or operational advantage; and that turbine sites are predominantly barren, treeless ridges rather than dense forest. We neither test nor endorse these, but our results are consistent with them: at every physically meaningful unit we find no preferential siting on burnt land, and the only positive signal is an artifact of administrative subdivision. Where our approach adds value is methodological, in showing that a base-rate denominator, a time-ordered test, and attention to the physical versus administrative unit are what a defensible answer requires, and that a naive base-rate analysis can otherwise produce a spurious licence-level association.

5.4 Limitations

Several limitations qualify the findings. CORINE is a single 2018 snapshot, and for fires occurring before 2018 it already reflects post-fire land cover, so the fuel covariate carries measurement error and probably under-adjusts; the true landscape-explained fraction may be larger than half, which would shrink the residual. The MODIS-based EFFIS product maps only fires above about 30 ha, so small fires are absent. Commissioning dates for bracketed stations use interval midpoints, and the incident-event set for Test C is small, between 165 and 229, so the time-ordered test has limited power and gives specification-dependent results. Test

B counts any within-window overlap, including post-installation fires, which is appropriate for a spatial-association question but not for a temporal one, and is the reason the temporal question is handled separately by Test C.

A limitation concerns fire origin versus extent. Our primary exposure is the extent of each burnt area, where a fire eventually reached, not where it was ignited, so a turbine can count as near a fire that spread to it from a distant origin, even though the accusation concerns where fires are started. We addressed this directly with satellite active-fire detections, taking the earliest detection inside each perimeter as its ignition point, and the result was null at every unit (Section 4.3). Two caveats remain: a satellite detection is a located hotspot with positioning error of a few hundred metres to about a kilometre, not a surveyed point of origin, and an ignition hotspot was recoverable for 97% of perimeters, leaving a small fraction of mostly small or brief fires unrepresented. The most direct test would use cause-attributed ground ignition records, such as the fire-service point data available from 2020 onward.

The analysis also addresses only whether siting is associated with burnt land; it does not assess the net effect of wind development on fire regimes, positive or negative, such as the role of access roads in suppression or of construction activity in ignition risk, which lies beyond its scope. Finally, the analysis speaks to the systematic pattern across the fleet, not to any individual project, which it can neither implicate nor exonerate.

5.5 A methodological lesson

Beyond the Greek case, the study offers a transferable caution. The answer to ”are these locations preferentially on land of type X” depends jointly on the unit of analysis, the spatial scale at which exposure is measured, and the completeness of the landscape controls, and moving any of the three can turn a null into a significant effect or the reverse. This case adds a specific warning: administrative permit boundaries can manufacture an association that disappears under physical aggregation, so the unit should be chosen to match the physical question rather than the paperwork. Honest treatment of all these choices, rather than the selection of whichever combination yields the cleanest message, is what separates a defensible finding from an artefact. The base-rate and time-ordered framework used here is portable to other contested siting claims in fire-prone regions and elsewhere.

6. Conclusions

Across temporal-precedence, spatial case-control, and time-ordered survival tests, evaluated from the parcel to 5 km and interrogated for landscape confounding, unit definition, and time gaps, we find no evidence that wind turbines in Greece are deliberately sited on burnt land, and no robust evidence of preferential siting at any physically meaningful unit. A landscape-scale association appears only when administrative licences are counted as independent units; it is absent at the turbine scale and at every physical grouping of turbines, and is best understood as an artifact of administrative subdivision in shared fire-prone terrain. Wind farms occupy fire-prone landscapes because wind resources and fire risk coincide on the same dry, exposed uplands, not because burnt land is targeted, and the long fire-to-installation gaps and fragile time ordering give no support to deliberate burning. The main lessons are methodological and transferable: the answer to a contested siting claim depends on the base rate, the catchment scale, the completeness of landscape controls, and, as this case shows sharply, on whether the unit of analysis is physical or administrative. Locating each fire at its ignition point with satellite active-fire detections, rather than the extent it reached, leaves every test null and so reinforces the conclusion; a still more direct test would use cause-attributed ground ignition records.

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Conflicts of interest

The author declares no conflicts of interest.

Software and reproducibility

Analyses were implemented in Python using geopandas and rasterio for geospatial processing, statsmodels for the logistic models (Seabold & Perktold, 2010), lifelines for the time-varying Cox model (Davidson-Pilon, 2019), and scikit-learn for the permutation inference. All derived datasets and the full analysis code are openly archived (see Data availability).

Data availability

The derived datasets, including the merged fire perimeters, the eligible-universe raster, the terrain and land-cover layers, and the case-control and per-farm tables, together with the full analysis code, are openly archived on Zenodo (https://doi.org/10.5281/zenodo.21261873). Input products are third-party and used under their own licences: the RAAEY registry, OpenStreetMap, Copernicus EFFIS, the Global Wind Atlas, the Copernicus GLO-90 digital elevation model, CORINE, Natura 2000, and NASA FIRMS active-fire detections.

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