# TREE UPROOTING IN THE SUCHEDNIÓW AREA (KIELCE UPLAND) AFTER THE SEVERE STORM OF 23 JUNE 2025 – EVENT ANALYSIS

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**Wojciech Nadziałek**
**Tomasz Kalicki**
Department of Geomorphology and Geoarchaeology, Institute of Geography and Environmental Sciences, Jan Kochanowski University in Kielce, **Poland**

## ABSTRACT

Severe convective storms accompanied by strong wind gusts represent an important natural hazard affecting forested areas in Poland. On 23 June 2025, such an event occurred in the Suchedniów area (Kielce Upland), resulting in extensive tree uprooting. Tree uprooting (uprooting denudation) is a geomorphological process involving the extraction of soil and sediment together with tree root systems, followed by their short-distance transport and redeposition. The aim of this study was to analyze the meteorological and geomorphological conditions associated with the storm, with particular emphasis on tree uprooting. The research was based on field investigations, including measurements of uproot pit dimensions, soil sampling, and photographic documentation of storm-related damage. Radar imagery was used to assess the spatial characteristics of the event, while sediment samples were subjected to granulometric analysis. Field surveys in the Kruk Forest District showed that approximately 51 m³ of material was displaced over an area of about 2 ha, mainly on sandy soils. Some uproots displayed a distinct bipartite structure composed of humus-rich soil and lighter substrate material, separated by a sharp boundary related to the former root system. This structure suggests that similar storm-induced uprooting denudation may have occurred in the past, highlighting the long-term geomorphological significance of severe wind events.

Keywords: windthrow, tree uprooting, severe thunderstorm, strong wind, Kielce Upland

## INTRODUCTION

A thunderstorm is a weather phenomenon characterized by the occurrence of atmospheric discharges accompanied by thunder [1]. Although not every convective cell generates hazardous weather phenomena, there are particularly destructive storm forms, including supercell thunderstorms [2]. These are often associated with violent wind gusts, torrential rainfall, and large hail. Strong winds during thunderstorms are most linked to intense downdrafts of cooled air within the storm cloud, referred to as a downburst. Depending on their spatial extent, microbursts and macrobursts are distinguished [3]. Significant wind gusts may also occur along squall lines [4]. Such phenomena can result in serious damage, including impacts on buildings, infrastructure, and forest stands.
In forested areas, the effects of severe winds frequently include windthrow and uproot denudation, involving the uprooting of soil together with the tree root system [5]. Although this phenomenon is most observed in the Sudetes and the Tatra Mountains [6], it also occurs in other regions of Poland, including the Kielce Upland, where it was recorded on 23 June 2025 in the Suchedniów Forest District.

## METHODS

The primary objective of this study was to conduct a detailed examination of the meteorological and geomorphological conditions associated with the development and impacts of the investigated storm event, with particular emphasis on the occurrence and characteristics of tree windthrow. All fallen trees within the study area were measured in accordance with the methodology described by Norman et al. [7]. Each windthrow was treated as a rotational ellipsoidal root plate characterized by three unequal axes (Fig. 1). The measurement procedure involved determining the length, width, and depth of the root plate, followed by calculation of its volume using the formula:

$$V = \pi hda/6$$

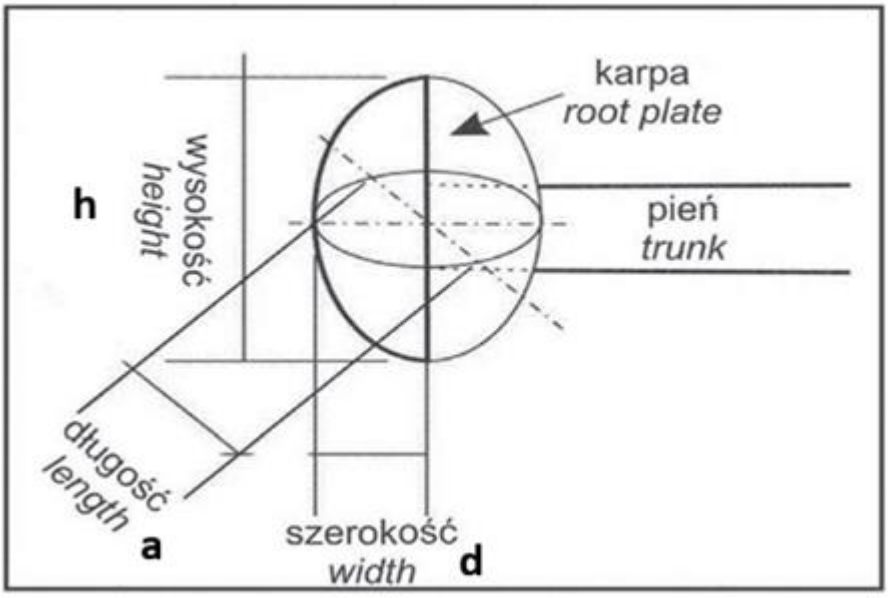



**Figure 1.** Main parameters of the root plate based on Pawlik 2012 [6] – modified.

In addition, comprehensive photographic documentation of storm-related damage was compiled, while radar data were employed to perform a spatial analysis of the event. Laboratory-based granulometric analyses of sediment samples were also conducted to determine grain-size distribution. The analytical results were graphically presented using the GRANULOM software.

## STUDY AREA

The Suchedniów Forest District is an organizational unit of the State Forests under the authority of the Regional Directorate of State Forests in Radom. It is located in the Świętokrzyskie Voivodeship and encompasses areas within the Skarżysko, Kielce, Końskie, and Starachowice counties. The total area of the forest district is approximately 369 km², of which around 185 km² are forests managed by the State Forests [8]. According to the physical-geographical regionalisation of Poland, the Suchedniów Forest District is situated within the Małopolska Upland, part of the Kielce Upland microregion (Fig. 2.). It encompasses several mesoregions, including the Suchedniów Plateau, the Gielniów Hump, and the Świętokrzyskie Mountains [9], [10]. The landscape is

predominantly upland, with elevations exceeding 300 m a.s.l., and is dissected by numerous river valleys, chiefly those of the Kamienna River and its tributaries. Based on the nature-forest regionalization framework, the district's forested area falls within the Małopolska region, corresponding primarily to the Świętokrzyska Forest mesoregion. The area lies within the natural distribution range of the principal tree species commonly occurring in Polish forests [11].

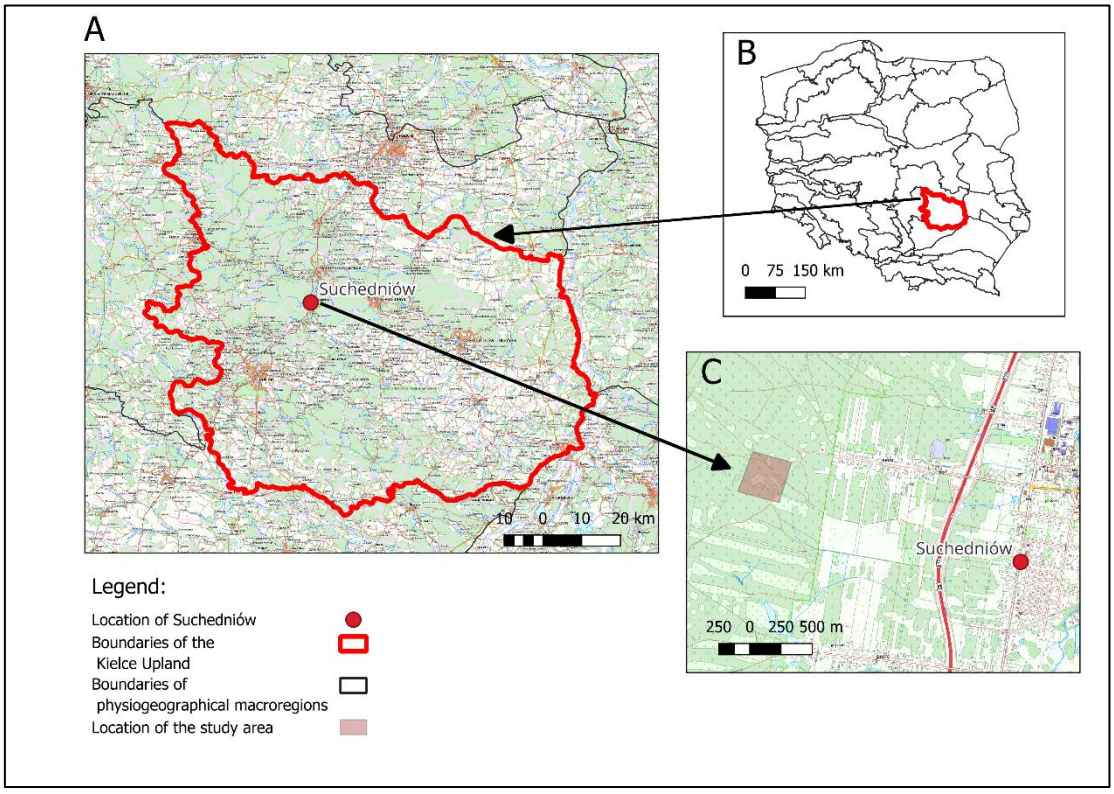



**Figure 2.** Location of the Kielce Upland within Poland (A), Suchedniów within the Kielce Upland (B), and the study area (C). Own elaboration based on GUGiK data [12].

## Meteorological Situation

On 23 June 2025, Poland was under the influence of strongly heated tropical maritime air masses advected from the south (Fig. 3). Both the European Centre for Medium-Range Weather Forecasts (ECMWF) [13] and the Global Forecast System (GFS) [14] indicated that these air masses would exhibit significant instability, with convective available potential energy (CAPE) reaching 1200–1400 J/kg. Such conditions were favourable for the development of severe thunderstorms. Additionally, a cold front was rapidly advancing across the country, enhancing strong vertical wind shear in both the lower and upper troposphere, with wind speeds reaching up to 25 m/s. These atmospheric conditions promoted the formation of an organized linear convective system, characterized by violent wind gusts.

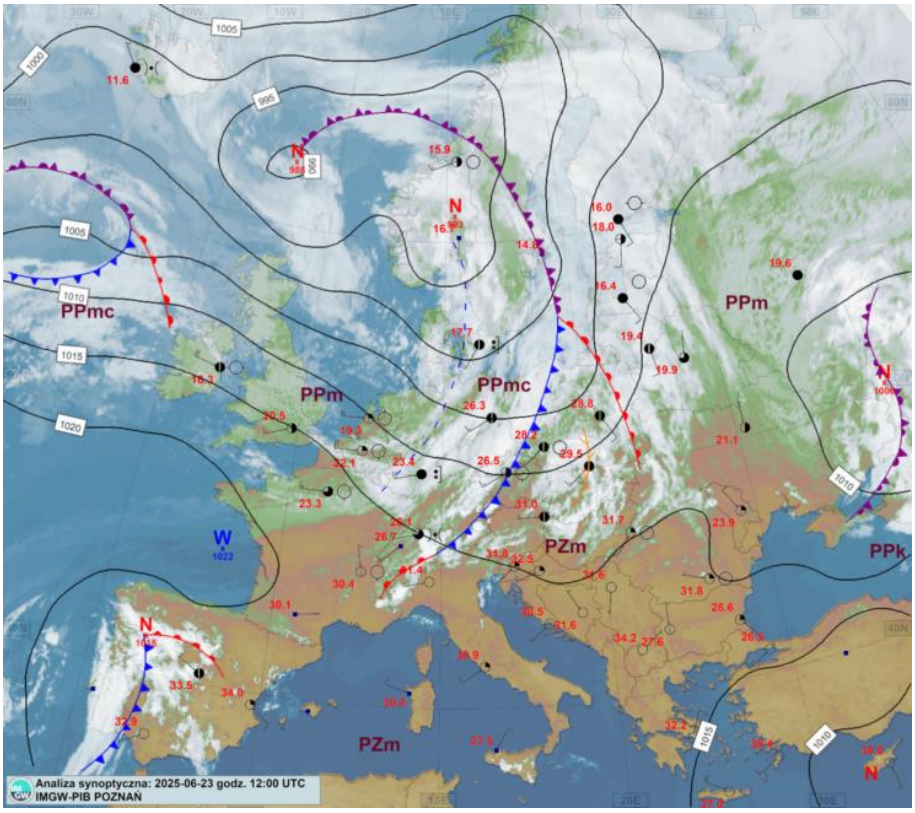



**Figure 3.** Synoptic map for 23 June 2025, 12:00 UTC, Meteo IMGW [15].

**Storm Development**

The thunderstorm developed around 17:00 over Lower Silesia. Relatively quickly, a convective system with a linear structure formed. By 18:00, a prominent shelf cloud had developed at its leading edge, the presence of which typically indicates the potential for severe wind gusts. The first wind-related damage was recorded in Silesia, including numerous fallen trees, damaged buildings, and affected power lines. The IMGW (Institute of Meteorology and Water Management) station at Szklarska Poręba registered a wind gust of 101 km/h. Reports from this area are also recorded in the European Severe Weather Database [16], with wind damage rated between 0 and 1.5 on the International Fujita Scale, suggesting probable local gusts of up to 180 km/h.

The convective system continued moving eastward. Its structure gradually disintegrated; however, the storm remained hazardous. Around 20:00, it reached the Kielce Upland. In the Suchedniów area, a bow-shaped segment redeveloped (Fig. 4). Unfortunately, no meteorological stations capable of measuring wind were located along the storm's path. The system caused extensive wind damage in the Suchedniów region, including damaged power lines and torn-off roofs. Numerous windthrows were recorded in the forests of the Suchedniów Forest District, along with the formation of uproots. The storm significantly affected the local dynamics of the forest ecosystem, and these areas were temporarily closed for safety reasons. The most severe forest damage was observed in the Kruk, Osieczno, Jastrzębia, Szałas, and Wilczy Bór forest compartments. Meteorologists from the European Severe Weather Database assessed the forest damage at IF1 on the International Fujita Scale (Fig. 5.). Wind gusts may have reached up to 150 km/h, although this occurred over a very limited area around Suchedniów. Less extensive wind

damage was also reported in other parts of the Kielce Upland, particularly in its southern region.

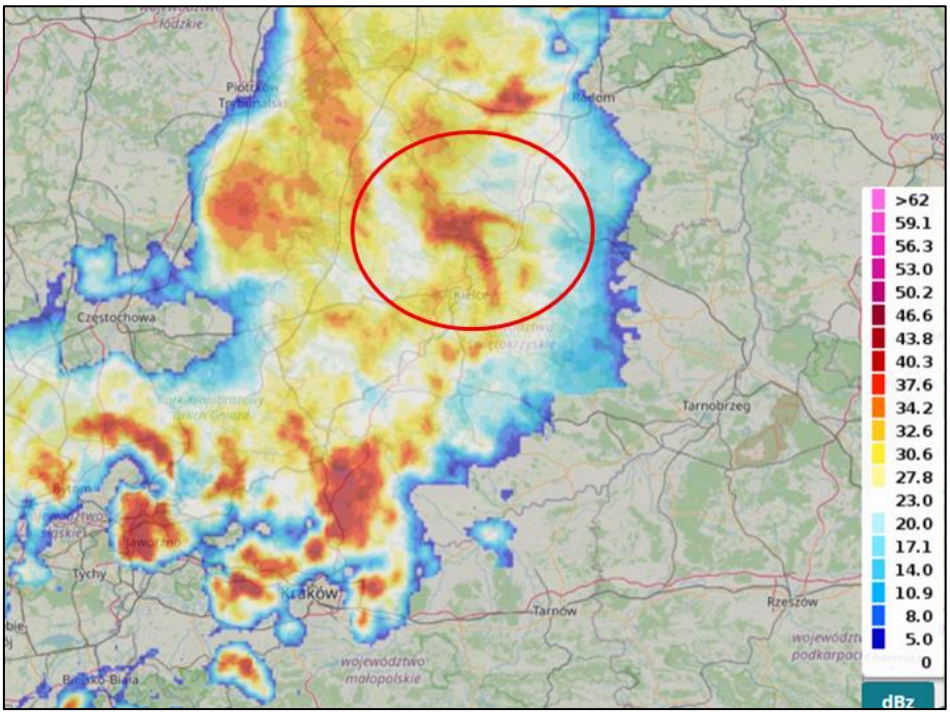



**Figure 4.** Radar scan from 23 June 2025, 19:20 UTC, Meteo IMGW [15]



**Figure 5.** Wind damage in the Suchedniów Forest District [17].

## Tree uprooting in Kruk Forest Compartment

The study was conducted with the approval of the forest district authorities in the Kruk Forest Compartment, located in the immediate vicinity of Suchedniów. Measurements of root plates indicated that, in the surveyed area (approximately 7 ha), 14 trees had been uprooted, with a total volume of exposed soil amounting to 51 m³ (Table 1), averaging

3.64 m³ per fallen tree. The most frequently uprooted species was European spruce (Picea abies) and Scots pine (Pinus sylvestris). Additionally, fallen specimens of oak (Quercus spp.) and birch (Betula spp.) were also recorded.

**Table 1.** Dimensions of root plates and the volume of eroded material in the Kruk Forest Compartment

| No. | Tree species | Height (m) | Length (m) | Depth (m) | Volume of eroded material ($m^3$) |
|---|---|---|---|---|---|
| 1 | Pine | 5 | 5,74 | 0,57 | 8,56 |
| 2 | Pine | 3,74 | 3,69 | 0,35 | 2,53 |
| 3 | Spruce | 2,57 | 3,9 | 0,61 | 3,20 |
| 4 | Oak | 3,34 | 4,89 | 0,62 | 5,30 |
| 5 | Birch | 2,64 | 3,62 | 0,51 | 2,55 |
| 6 | Pine | 1,62 | 3,04 | 0,73 | 1,88 |
| 7 | Pine | 1,53 | 1,94 | 0,77 | 1,20 |
| 8 | Spruce | 4 | 5,2 | 0,6 | 6,53 |
| 9 | Spruce | 2,2 | 1,48 | 0,9 | 1,53 |
| 10 | Pine | 1,9 | 2,9 | 0,35 | 1,01 |
| 11 | Pine | 1,92 | 1,72 | 0,92 | 1,59 |
| 12 | Pine | 2,89 | 3,6 | 0,64 | 3,48 |
| 13 | Spruce | 2,8 | 3 | 0,7 | 3,08 |
| 14 | Spruce | 4,3 | 4,9 | 0,77 | 8,49 |

The largest root plate measured 5 m in height, 5.74 m in width, and approximately 0.57 m in depth. Granulometric analyses indicated that root plates primarily occurred on sandy soils dominated by medium- and fine sands or silty sands. In contrast, the largest root plates developed on sands containing coarser materials, including gravel (Fig. 6.).

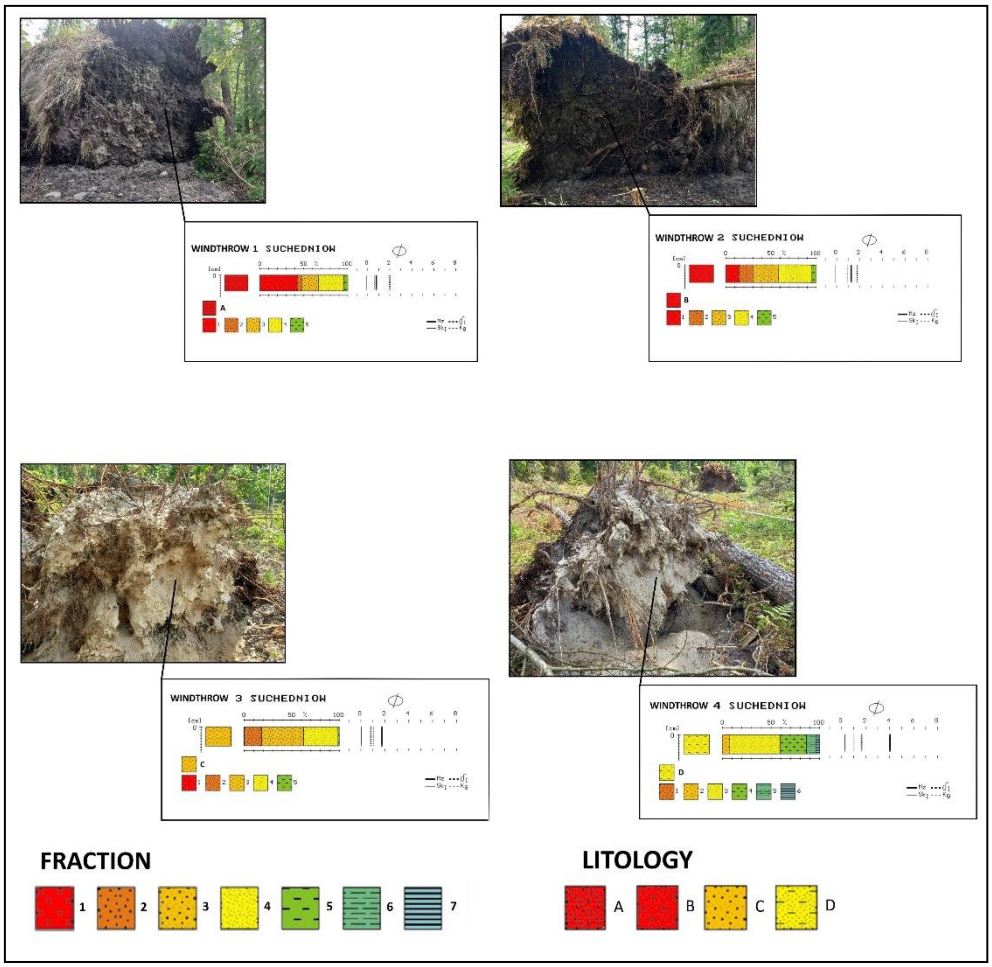



**Figure 6.** Granulometric composition of the root plates in the Kruk Forest Compartment, own elaboration. Fraction: 1 – gravel, 2 – coarse-grained sands, 3 – medium-grained sands, 4 – fine-grained sands, 5 – coarse-grained silts, 6 - medium- and fine-grained silts, 7 – clays Litology: A – sand with gravel, B - sand with occasional gravel, C - medium sand, D - loamy–silty sand. Folk–Ward parameters: Mz — mean grain size, $\sigma_1$ — standard deviation (sorting), SkI — skewness, KG — kurtosis.

An interesting observation was the color difference noted in some root plates (Fig. 7). Root plates typically exhibit a characteristic two-part structure: a dark, humus-rich section composed of the upper soil layers (layer A), and a lighter section consisting of subsoil material lifted by the root system (layer B). During the infilling of the cavity, the humus-rich portion is rapidly deposited, followed by the slow settling of subsoil material as it detaches from the roots [18]. Colour variations in the sediments may indicate that a given root plate formed at the site of a previous tree fall.



**Figure 7.** Root plate showing visible colour differentiation, photo: Wojciech Nadziałek.

## CONCLUSION

The analyzed event constituted an extensive linear convective system that developed along a cold front displacing unstable tropical air mass. During its passage, the storm generated destructive wind gusts associated with downburst phenomena. In the forests surrounding the town of Suchedniów, the storm caused numerous tree falls, leading to the formation of root plates. Field measurements conducted in the Kruk Forest Compartment indicated that approximately 51 m³ of material was displaced from an area of 2 ha. Root plates occurred primarily on sandy soils dominated by medium- and fine-grained sands or clayey-silty sands. The largest root plates developed on sands containing coarser material, including gravel. Two-coloured root plate indicates previous occurrence of uproot denudation in the analyzed area.

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