Pullin test for root stability evaluation

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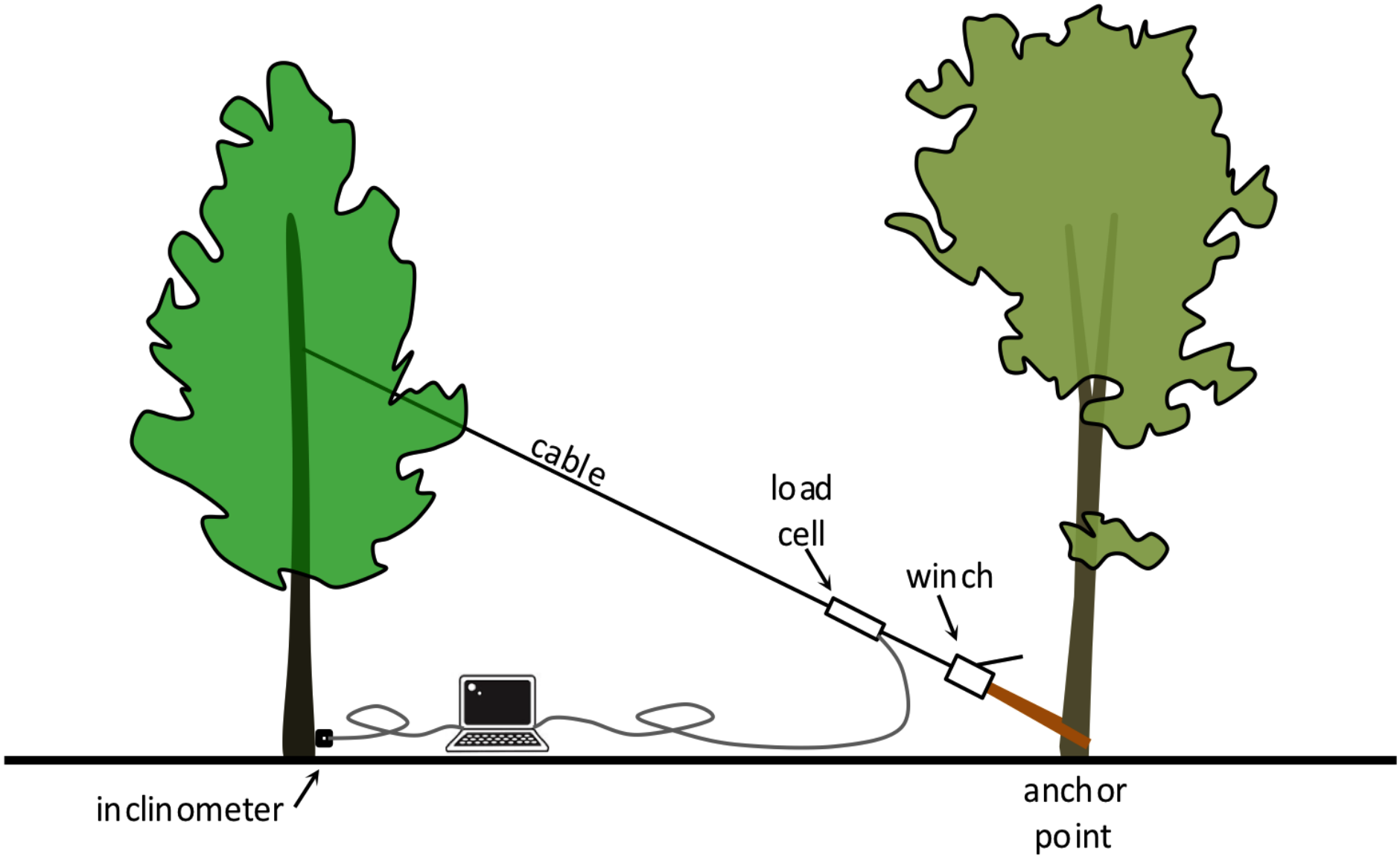
Presentation is restricted for root stability evaluation

Root stability evaluation is not an easy job ….

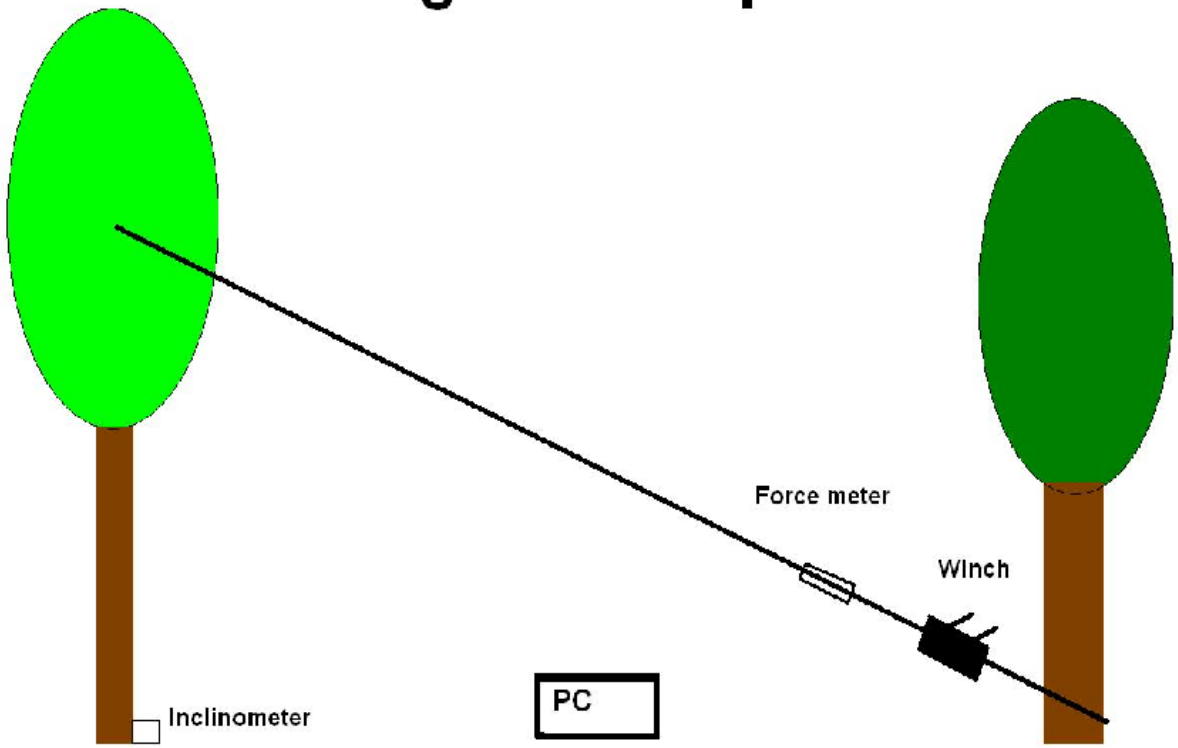
Available evaluation techniques are:

- Pulling test – inclino and
- Dynamic Root Evaluation, a new method!

Pulling test setup



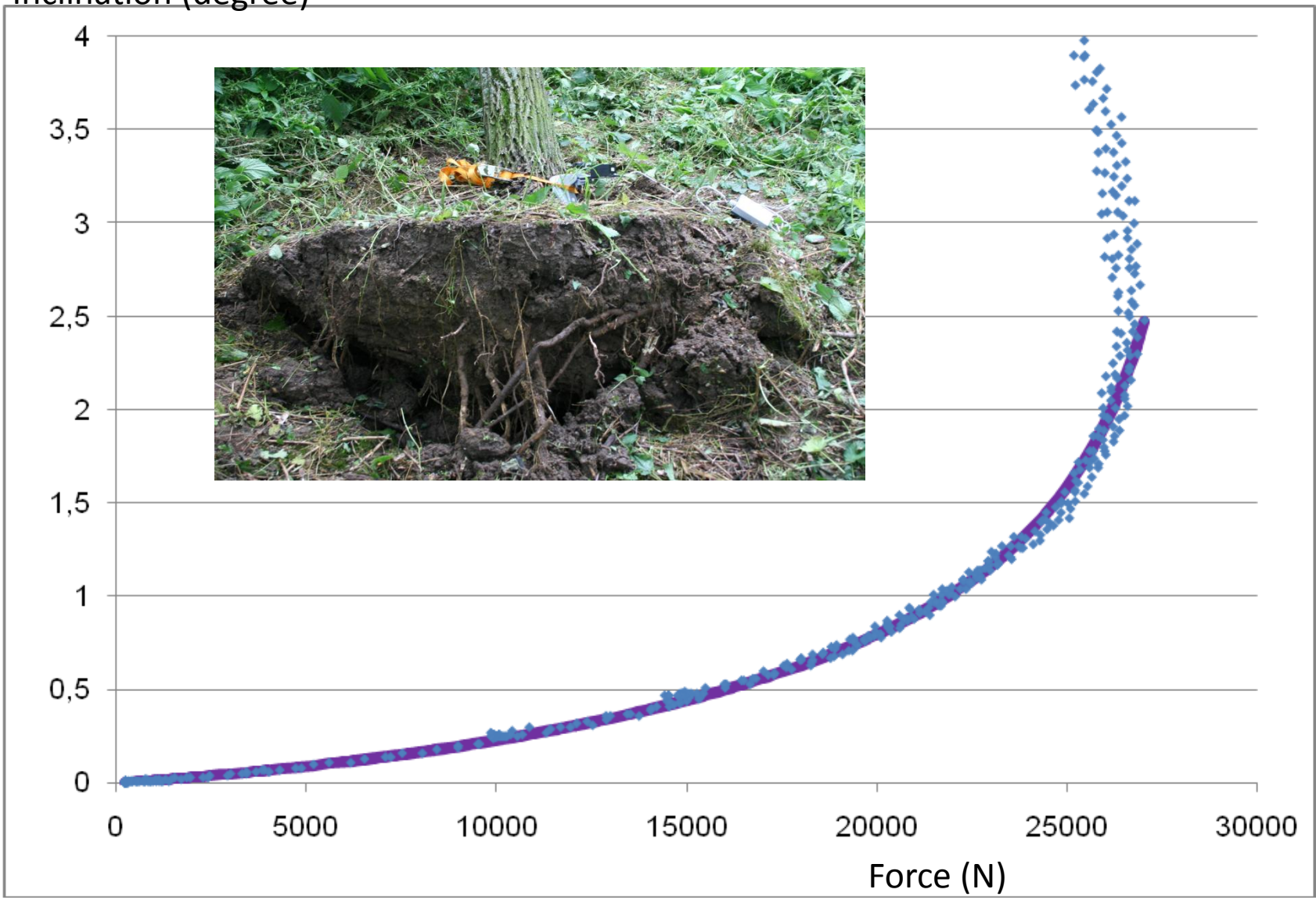
Pulling test setup



Inclination sensor

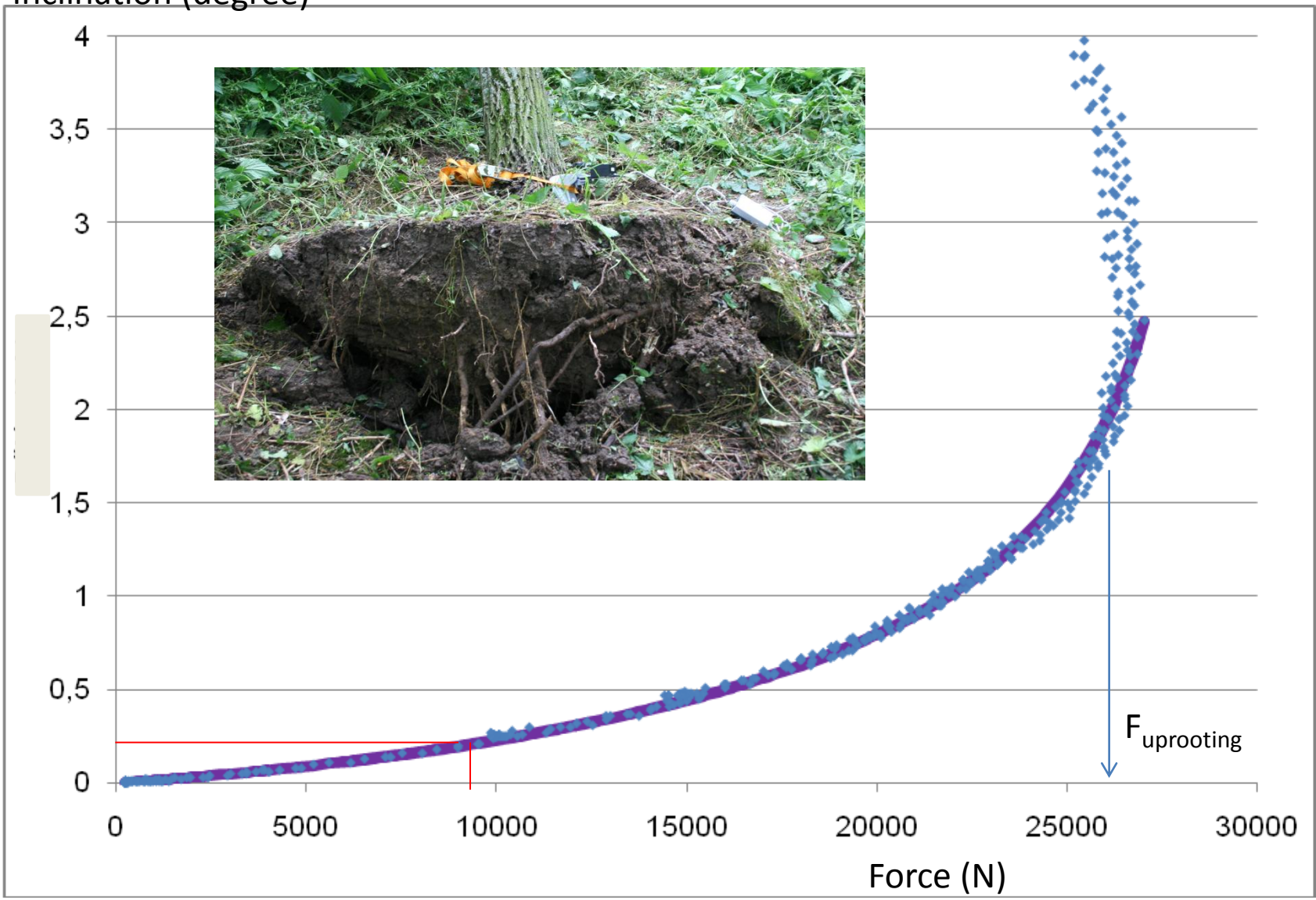
Force sensor and force display

Uprooting test



Above 2 degree inclination, uprooting force is not increasing. In a pulling test we stop at 0,2 degree inclination.

Uprooting robinia tree



Above 2 degree inclination, uprooting force is not increasing. In a pulling test we stop at 0,2 degree inclination.

Pulling test is in progress in Hungary.

Evaluation by extrapolation

Generalized inclination curve:

$\alpha = 1/3 \tan(p/73{,}85) + 0{,}00005\ p^2 - 0{,}0009\ p$

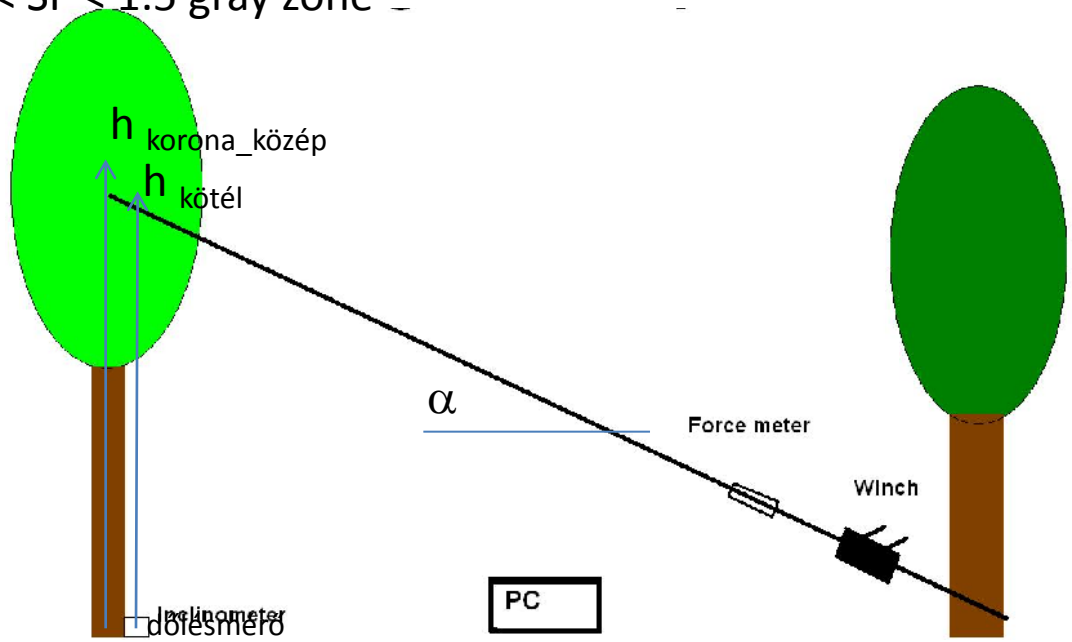
where: α: inclination in degree

p: force in % of maximum load = $F_{uprooting}$

Uprooting safety factor (SF) determination by pulling test

$$SF = \frac{M_{kifordít}}{M_{szél}} = \frac{F_{kifordít}\cos(\propto) h_{kötél}}{c0{,}5\,\rho V^2 A h_{korona\ közép}}$$

If SF > 1.5 the root system is safe
If SF < 1.0 the root system is dangerous
If 1.0 < SF < 1.5 gray zone

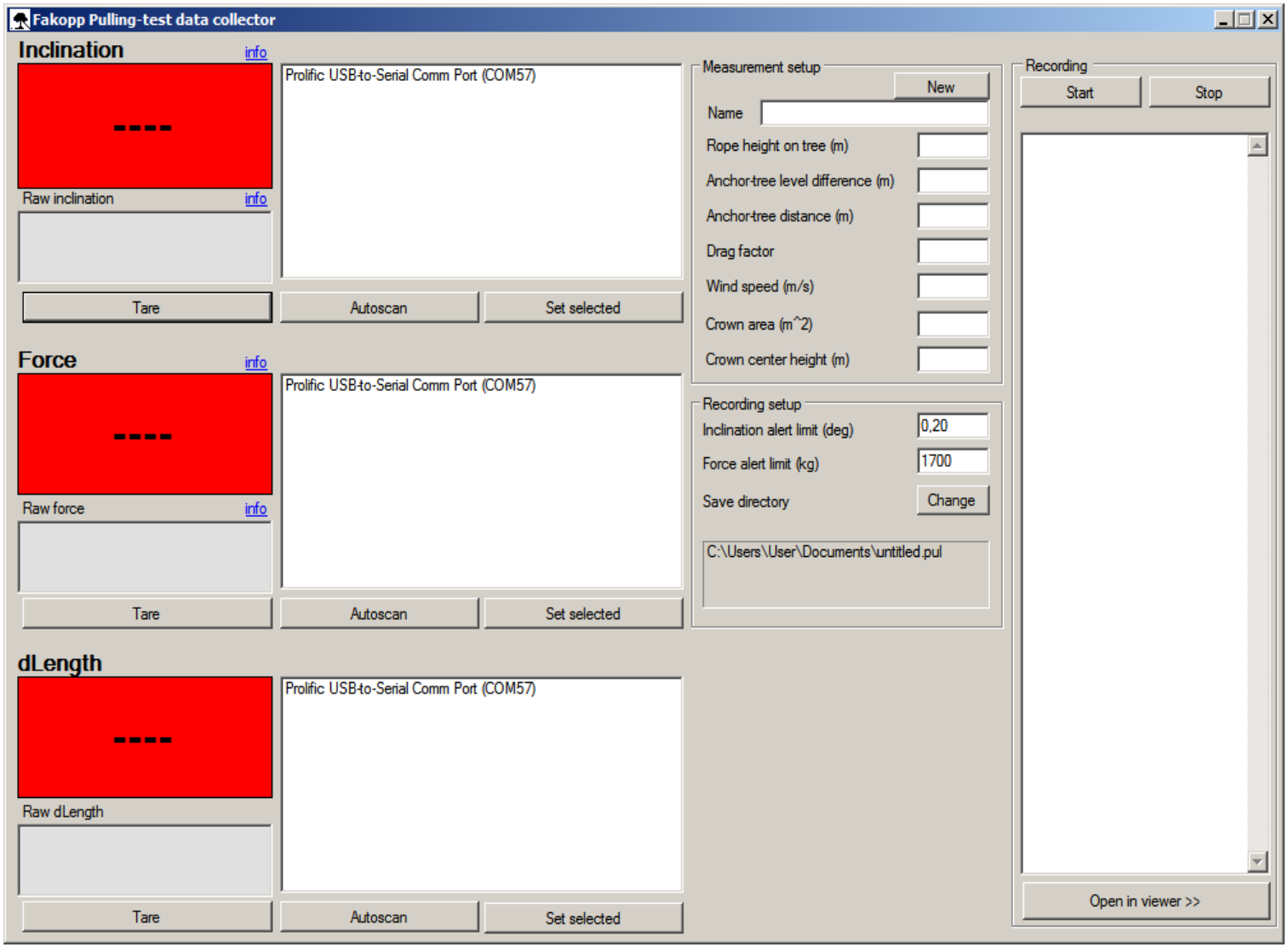


M: moment (Nm)
F : force (N)
ρ : air density (kg/m^3)
V : wind velocity (m/s)
A : crone area (m^2)
c : drag factor (-)
$F_{kifordít}$ *:* critical uprooting force (N)

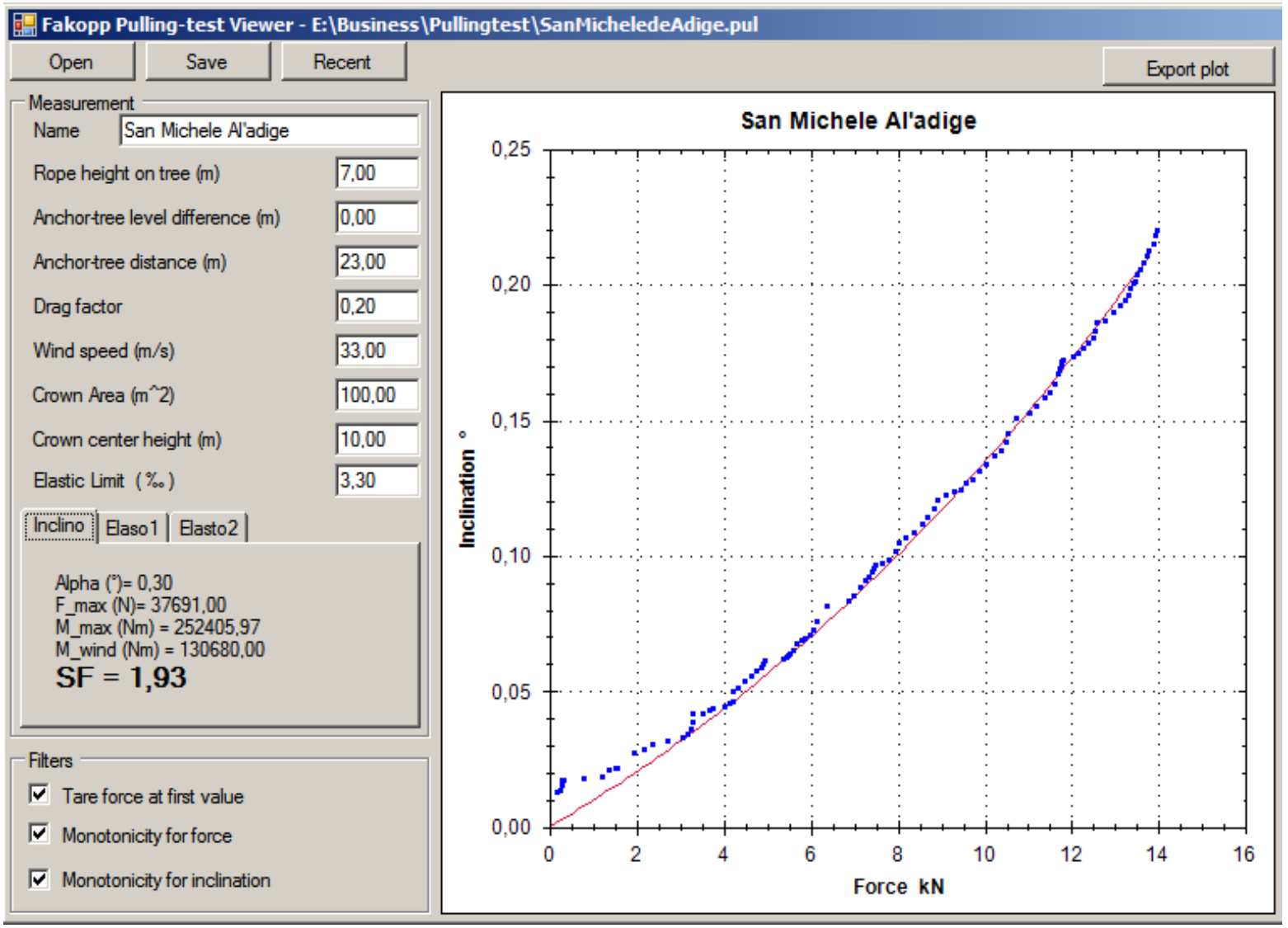
Table 1. Stuttgart table of wood strength (Wessolly and Erb 1998).

Species	Modulus of elasticity (N/mm^2)	Comparable strength in longitude (N/mm^2)	Elastic limit (%)	Proposed Aerodynamic drag factor (c_x)
Abies alba	9500	15	0.16	0.20
Acer pseudoplatanus	8500	25	0.29	0.25
Acer negundo	5600	20	0.36	0.25
Acer campestre	6000	25.5	0.43	0.25
Acer saccharinum	6000	20	0.33	0.25
Acer saccharum	5450	20	0.37	0.25
Aesculus hippocastanum	5250	14	0.26	0.35
Ailanthus altissima	6400	16	0.25	0.15
Betula pendula	7050	22	0.31	0.12
Chamaecyparis lawsonia	7350	20	0.27	0.20
Cedrus deodora	7650	15	0.20	0.20
Fagus sylvatica	8500	22.5	0.26	0.25–0.30
Alnus glutinosa	8000	20	0.25	0.25
Fraxinus excelsior	6250	26	0.42	0.20
Picea abies	9000	21	0.23	0.20
Picea omorika	9000	16	0.18	0.20
Carpinus betulus	8800	16	0.18	0.25
Castanea sativa	6000	25	0.42	0.25
Cercis siliquastrum	0	15	—	0.20
Larix decidua	5035	17	0.32	0.15
Liriodendron tulipifera	5000	17	0.34	0.25
Pinus pinaster	8500	18	0.21	0.20
Pinus sylvestris	5800	17	0.29	0.15
Platanus × hybrid	6250	27	0.43	0.25
Populus × *canescens*	6050	20	0.33	0.2–0.25
Populus nigra 'Italica'	6800	16	0.24	0.30
Populus nigra	6520	20	0.31	0.2
Populus alba	6400	20	0.31	0.2
Pseudotsuga menziesii	1000	20	0.20	0.20
Pyrus communis	5800	17	0.29	0.30
Quercus robur	6900	28	0.41	0.25
Quercus rubra	7200	20	0.28	0.25
Robinia pseudoacacia	7050	20	0.28	0.15
Robinia monophyla	5200	20	0.38	0.15–0.20
Salix alba	7750	16	0.21	0.20
Salix alba 'Tristis'	7000	16	0.23	0.20
Sequoiadendron gigantum	4550	18	0.40	0.20
Sophora japonica	6450	20	0.31	0.15
Sorbus aria	6000	16	0.27	0.25
Tilia x *hollandica*	4500	17	0.38	0.25
Tilia euchlora	7000	17.5	0.25	0.25
Tilia tomentosa	8350	20	0.24	0.25–0.30
Tilia platyphyllos	8000	20	0.25	0.25
Tilia cordata	8300	20	0.24	0.25
Ulmus glabra	5700	20	0.35	0.25

Pulling test data collection software



Pulling test evaluation software



Tree root stability is OK!

Fakopp Zugversuch Betrachter - G:\Germany2014_Pulling\untitled15.pul

Öffnen | Speichern | Letzte | Graph speichern

Messung

Name: Baum 2

Seil Höhe am Baum (m)	5,56
Anker-Baum Höhenunterschied (m)	0,00
Anker-Baum Distanz (m)	11,1
Widerstandskoeffizient	0,25
Windgeschwindigkeit (m/s)	34,00
Krone Oberfläche	78,00
Krone Zentral Höhe	8,00

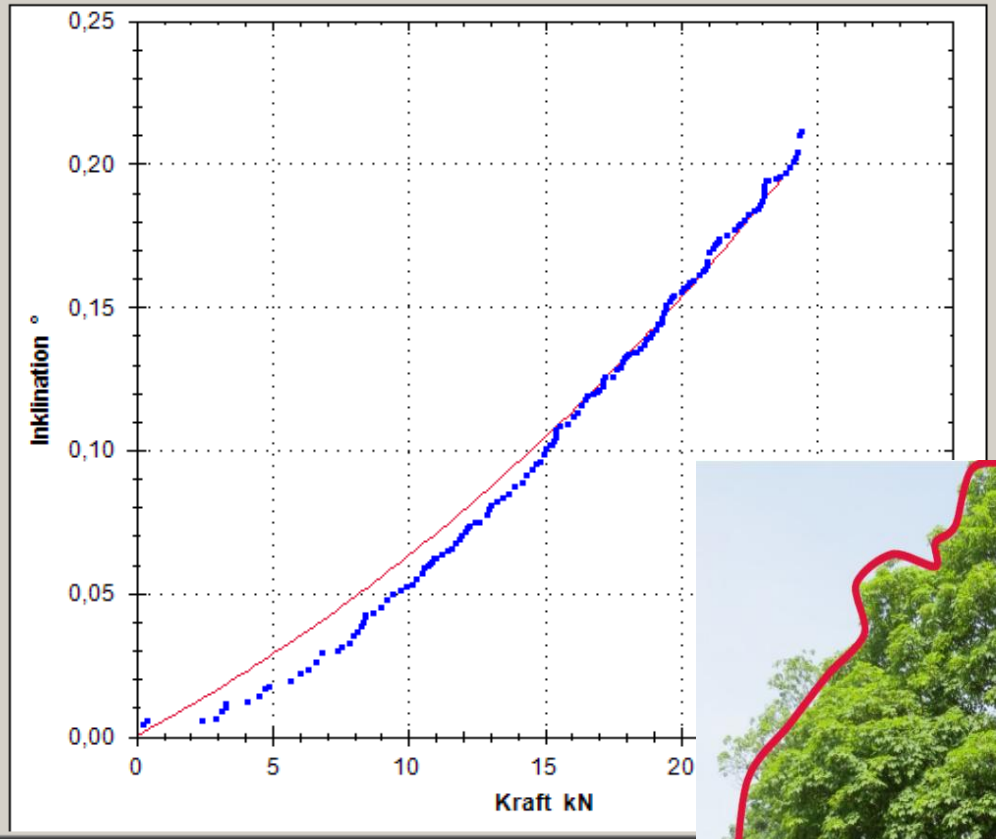
Resulte

Alpha (°)= 0,46
F_max (N)= 68505,19
M_max (Nm) = 340554,55
M_wind (Nm) = 108201,60

SF = 3,15

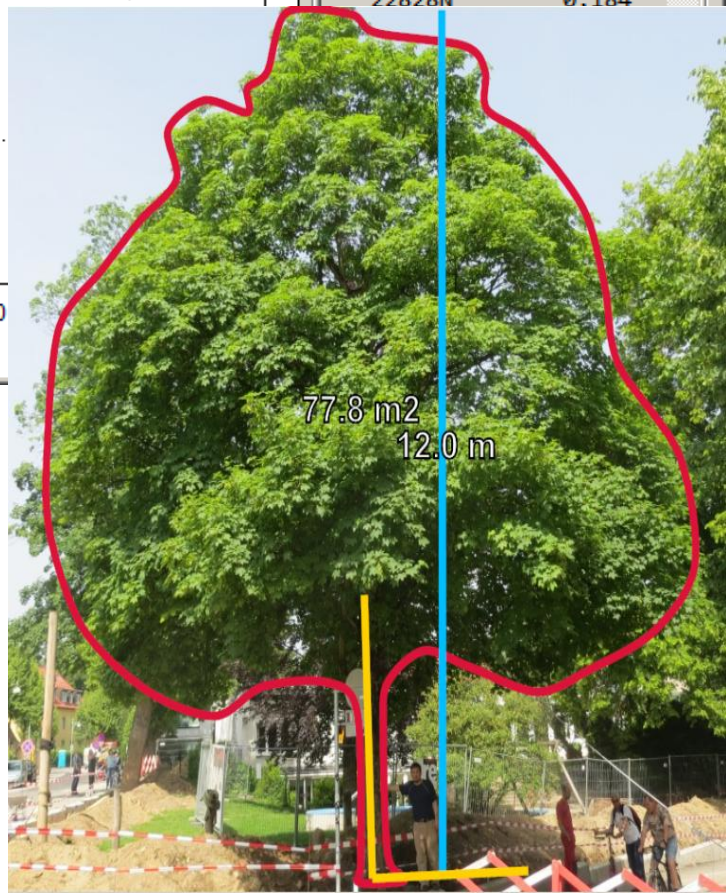
Filter

- [x] Tara Kraft bei erste Messpunkt
- [x] Monotonie für Kraft
- [x] Monotonie für Neigung



Datei

24466N	0,211°
24388N	0,210°
24299N	0,204°
24241N	0,202°
24142N	0,201°
24005N	0,198°
23838N	0,196°
23672N	0,195°
23505N	0,195°
23201N	0,194°
23132N	0,194°
23103N	0,192°
23093N	0,191°
23054N	0,189°
22985N	0,187°
22916N	0,185°
22828N	0,184°



Error sources

Quantity	Typical error	Typical value	Relative error (%)
$F_{uprooting}$	15 kN	100 kN	15
Rope angle (α)	0	30	0
h_{cable}	0,2 m	10 m	2
Crone area (A)	5 (m^2)	100 (m^2)	5
Air density (ρ)	0,05 kg/m^3	1,25 kg/m^3	4
Crone center height	1 m	10	10
Wind velocity (v)	???	34 m/s	-

Errors are given in „1σ" or 67% confidence level
The relative error of SF using the error propagation formula is 19,2% .

Increasing the confidence level to „2σ" or 95% the relative error of SF is **38,4%**

Other influencing factors:

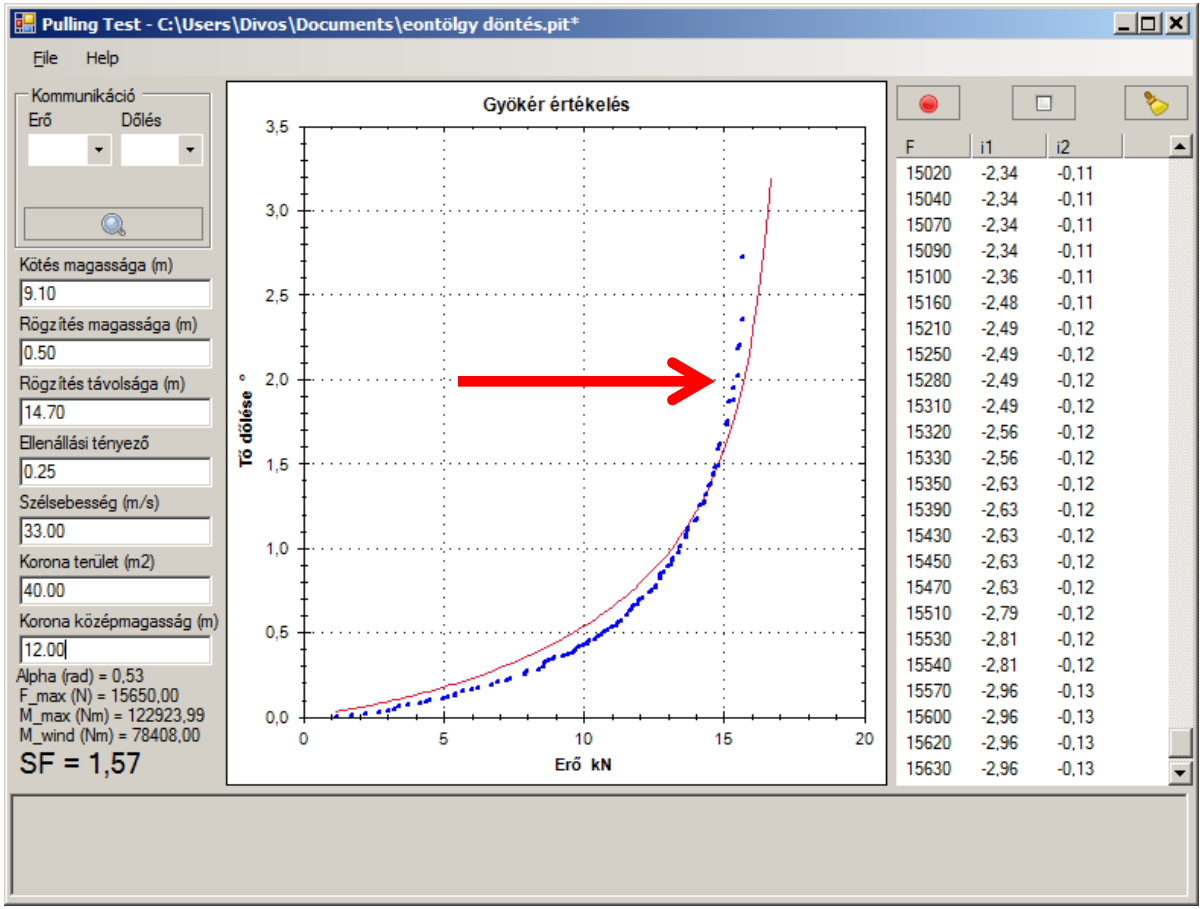
Effect soil moisture contetnt – preparation around oak tree

Effect of soil moisture contetnt – 300mm rain is simulated

Effect of soil moisture contetnt uprooting by bulling

Effect of soil moisture contetnt uprooting by bulling

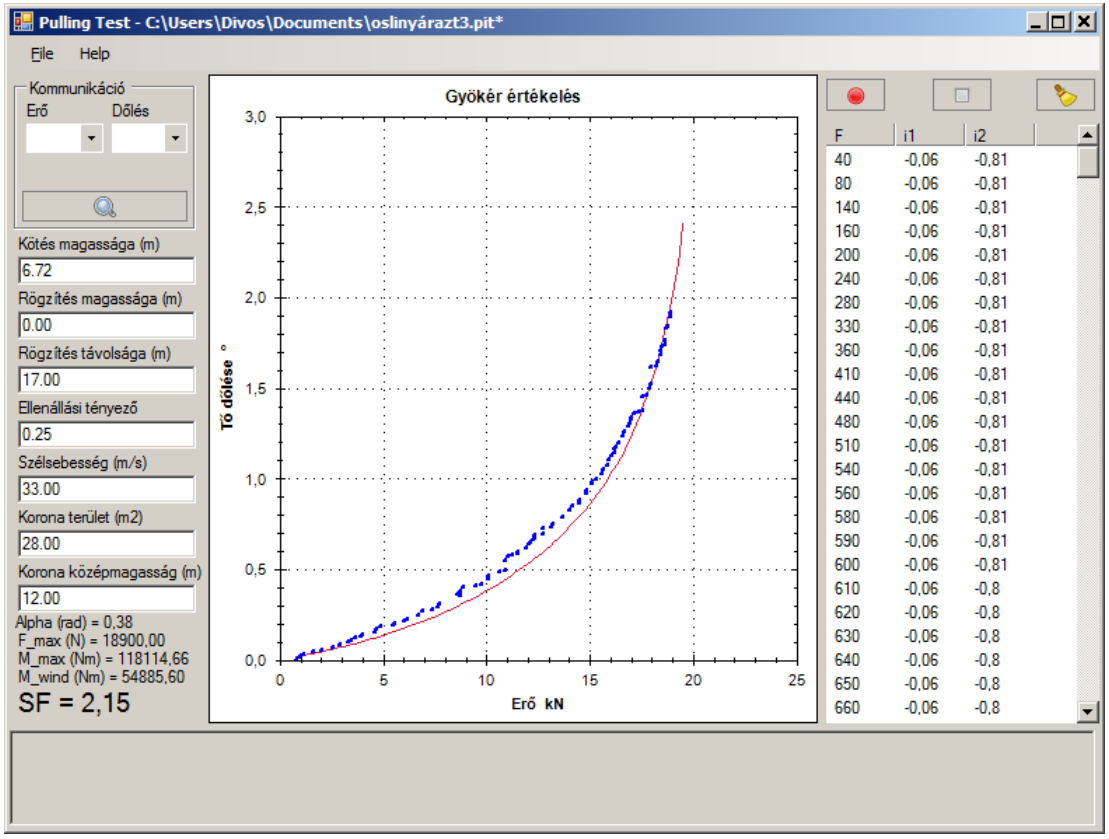
Oak pulling curve



Tölgyfa döntése. A döntés során felvett maximális erő: 15.7 kN

Effect of soil moisture contetnt uprooting a poplar tree by pulling

Poplar pulling curve



Olasz nyár. A 3. öntözést követte a fa kidöntése. A felvett maximális erő: 18,9 kN.

Effect of soil moisture content

- Result:

		Oak	Poplar
Initial condition	Extrapolated uprooting force	16,3 kN	19,0 kN
100 mm rain	Extrapolated uprooting force	15,0 kN	15,4 kN
200 mm rain	Extrapolated uprooting force	14,8 kN	14,9 kN
300 mm rain	Real uprooting force	15,7 kN	18,9 kN

- Conclusion: soil moisture content has minor effect on stability

Wind channel !!!

Taking into account the additional error sources, the tree roots are in good conditions if SF is higher than 1,5!

50% relative error covers all the error sources.


The new setup with central unit.
Benefit is: only one instrument is connected to PC.
Working with 2 inclinometers and 2 elastometers.
FAKOPP
PULLING TEST
Dual
Elastometer
FAKOPP
Pulling test
Central unit


Grazie per l'attenzione!