Kevin Lyons

Wes Lematta Professor in Forest Engineering
FERM, Oregon State University

- Office: Snell 311
- Phone: 541-737-5630
- Email: kevin.lyons@oregonstate.edu

Tether interaction with rub trees

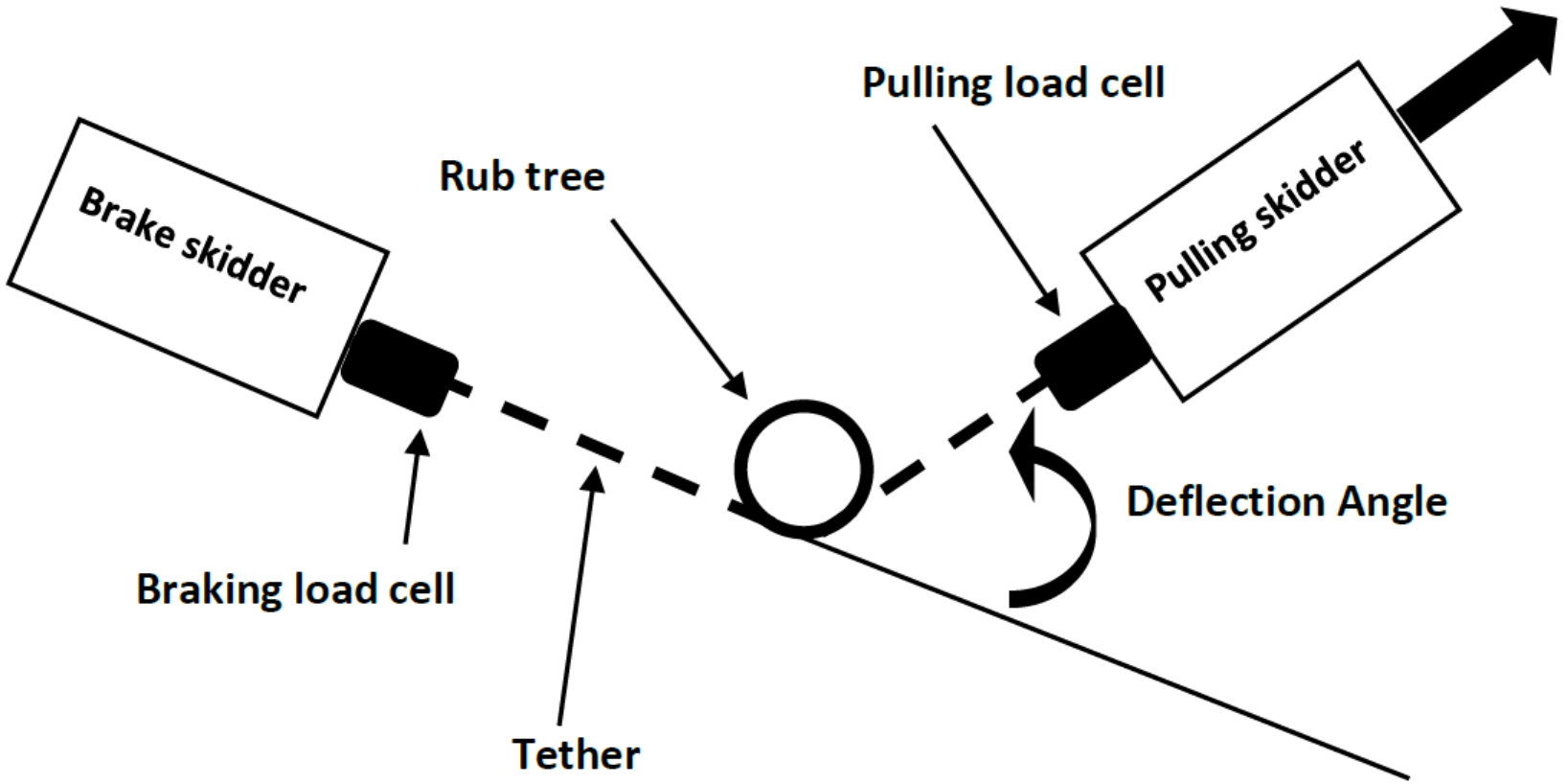
The effect on tether tension when using trees to redirect live machine tethers. Submitted to the Journal of Biosystems Engineering 11/26/2019.

C. Kevin Lyons*, Associate Professor, Dept. of Forest Engineering, Resources and Management, Oregon State University, Corvallis, Oregon, USA 97331, kevin.lyons@oregonstate.edu

John Sessions, Professor, Dept. of Forest Engineering, Resources and Management, Oregon State University, Corvallis, Oregon, USA 97331, john.sessions@oregonstate.edu

Jeffrey Wimer, Instructor, Dept. of Forest Engineering, Resources and Management, Oregon State University, Corvallis, Oregon, USA 97331, Jeffrey.Wimer@oregonstate.edu

170 degree change in angle. 2 year old stump. Test July 19, 2019

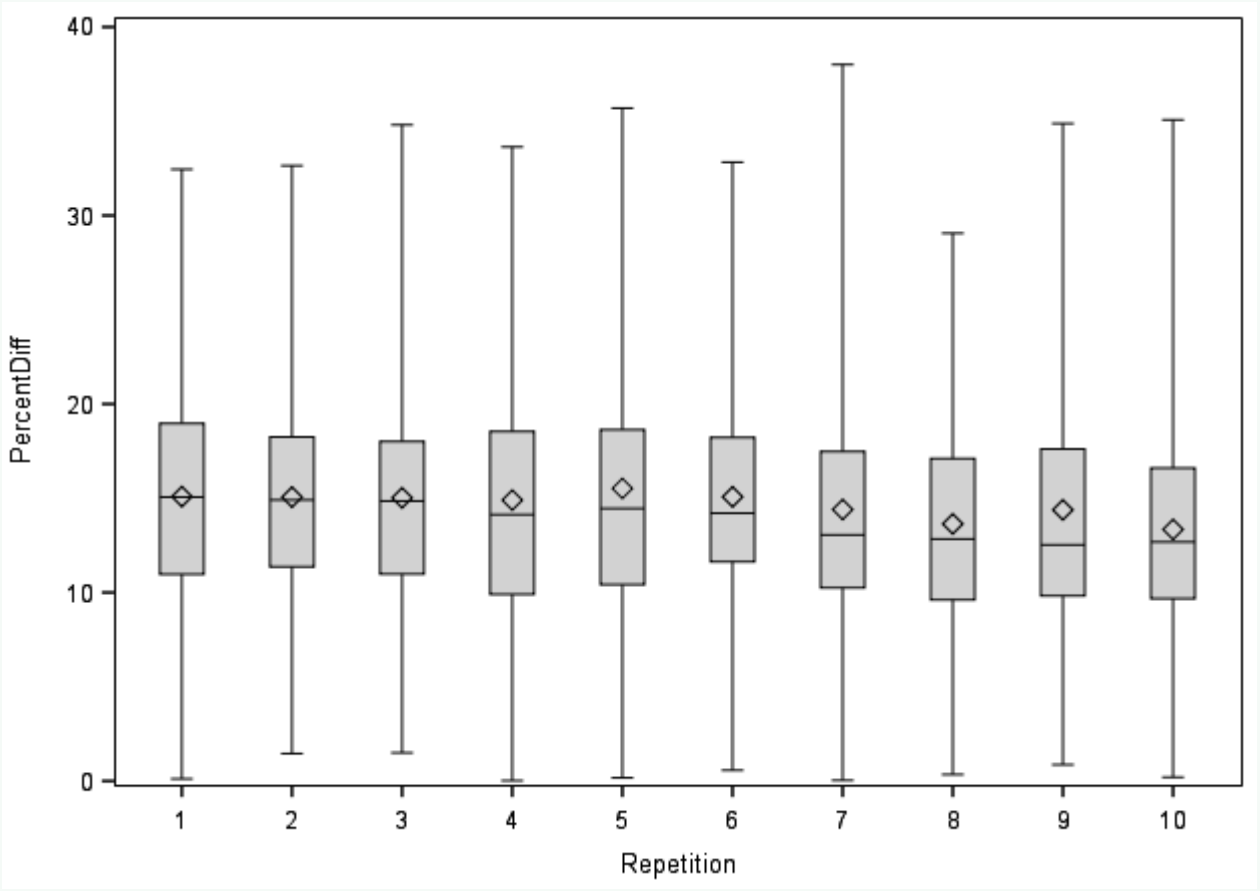

Brake skidder
Rub tree
Pulling load cell
Pulling skidder
Deflection Angle
Braking load cell
Tether

170 degree change in angle. 2 year old stump. Test July 19, 2019

Notice the shavings below the cable

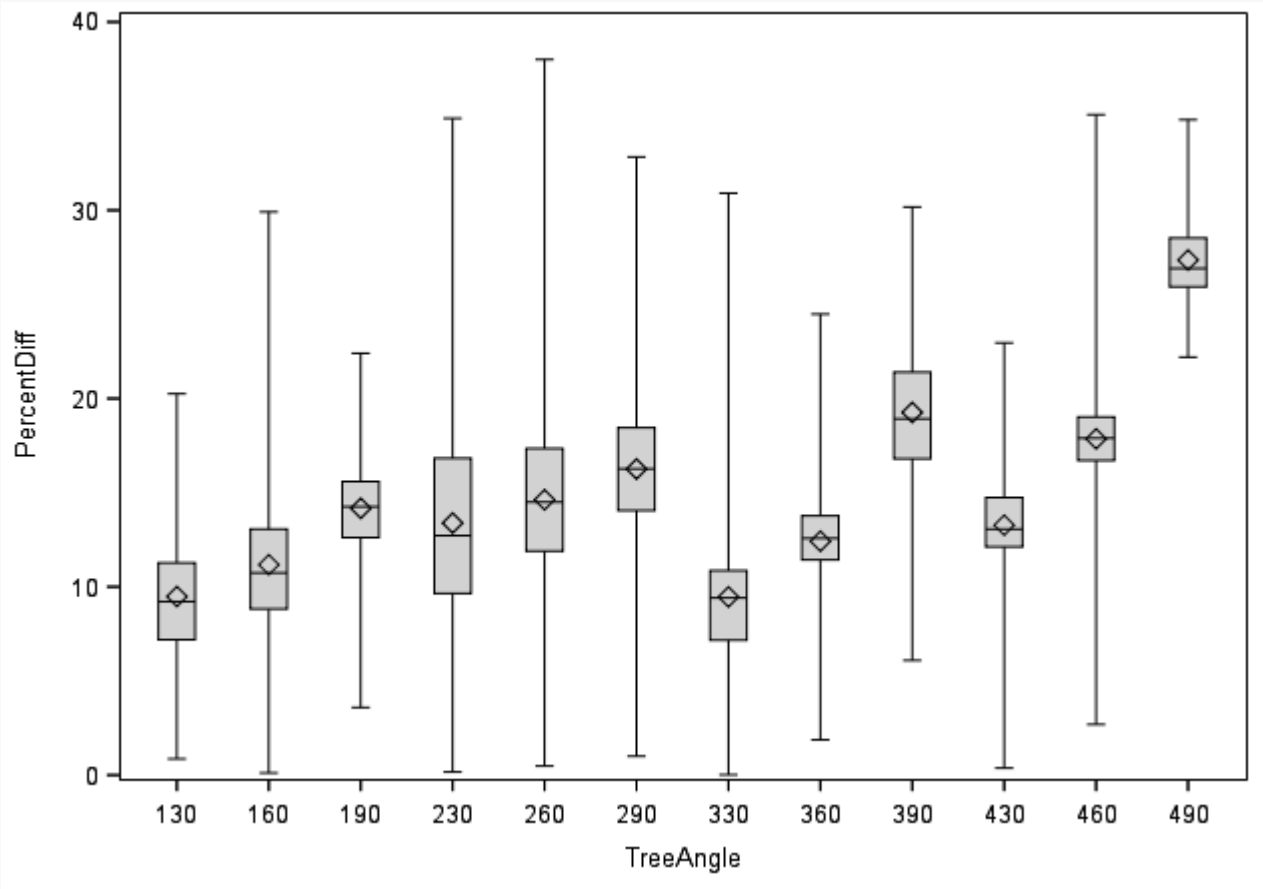
10 repetitions of pulling about 10m each repletion.

Can easily have unintentional rub trees



A repetition = 10m pull with target tension of 15,000 lb

Very little difference in PercentDiff as the number of repetitions increased.



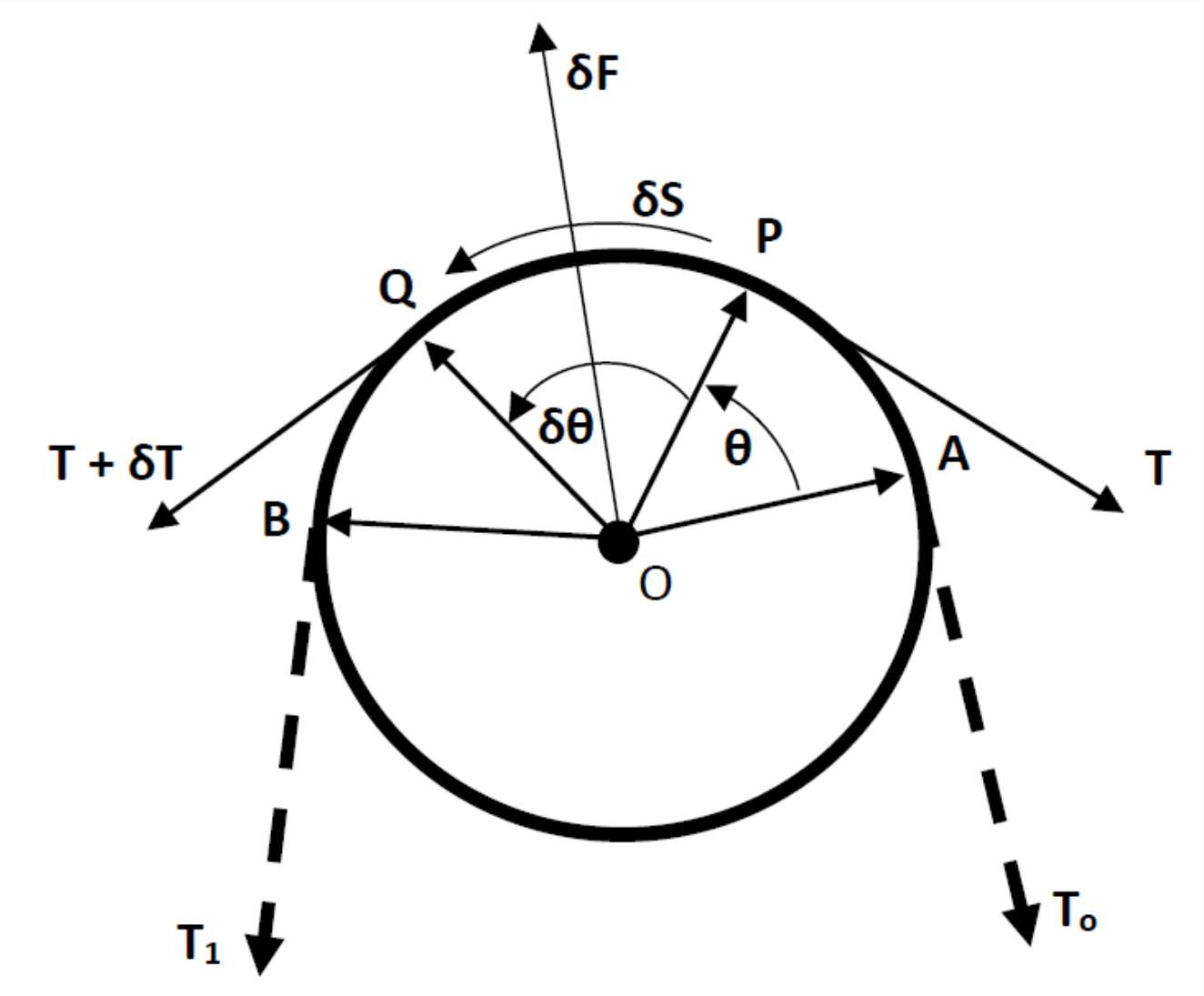
130 = Tree 1 and 30 degree deflection angle

Box plot:

- bottom and top of box are 25th and 75th percentiles
- Bar is the median
- Diamond is the mean
- Whiskers are the minimum and maximum

PercentDiff is the ratio of the pull side tension to the brake side tension as a percent.

What value to use in design?



Using force equilibrium on the differential element

$$\frac{dT}{d\theta} - \mu T = kR$$

Here: k is the cutting coefficient, and μ is the friction coefficient

Applying an integrating factor and integrating with respect to θ

$$T_1 = \frac{kR}{\mu}\left(e^{\mu\theta_T} - 1\right) + T_o e^{\mu\theta_T}$$

Rewriting to more clearly show the contribution of the cutting deformation and the friction forces.

$$T_1 = \frac{13.4R}{0.087}\left(e^{0.087\theta_T} - 1\right) + T_o\left(e^{0.087\theta_T} - 1\right) + T_o$$

Cutting force

Friction force

Brake tension

Estimates of across the grain cutting and friction forces given $\mu = 0.087$, $k = 13.4$, and $T_o = 60kN$.

R	θ_T	Cut Force (kN)	Friction force (kN)	Cut force (kN)	Cut force (kN)
(m)	(Radians)	1st term Eq(15)	2nd term Eq(15)	Eq(16) Ub=22000	Eq(16) Ub=12500
0.30	0.52	2.2	2.8	8.0	2.2
0.45	0.52	3.2	2.8	11.9	3.3
0.60	0.52	4.3	2.8	15.9	4.4
0.30	1.05	4.4	5.7	15.9	4.4
0.45	1.05	6.6	5.7	23.9	6.6
0.60	1.05	8.8	5.7	31.8	8.8
0.30	1.57	6.8	8.8	23.9	6.6
0.45	1.57	10.1	8.8	35.8	9.9
0.60	1.57	13.5	8.8	47.8	13.2

Summary

- Mechanical process is different from Coulomb Friction
- Tether quickly cuts a groove shaped to its own surface.
- Percent difference in tension does not change greatly with the distanced pulled.
- A model including a cutting force has been developed and can be calibrated to agree with similar models used in grinding.
- For management of tethers the maximum percent difference may be the important metric.
- For all trees and deflection angles considered, an upper range for percent difference could be 30%.

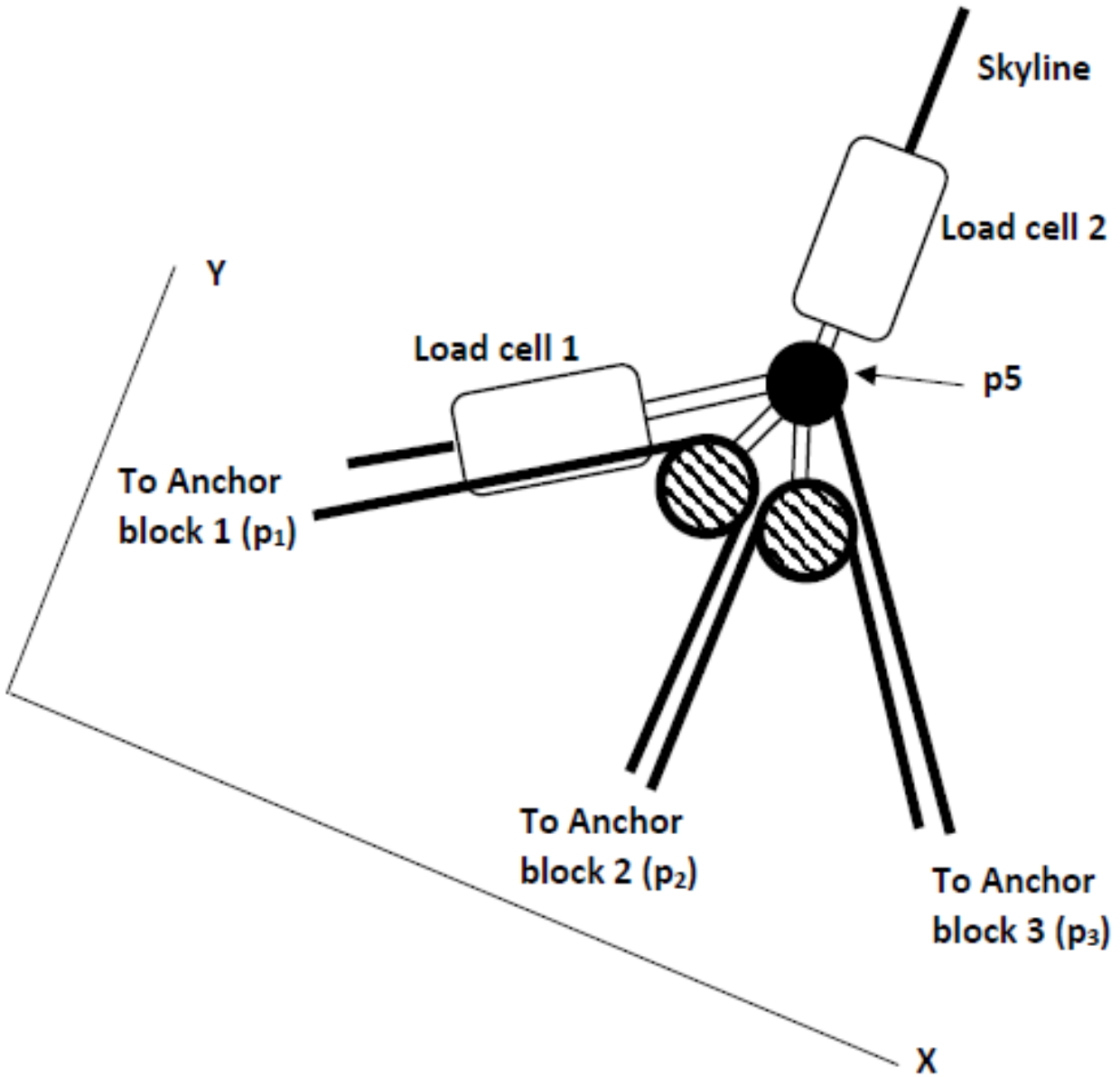
Continuous bridle multi-stump anchors

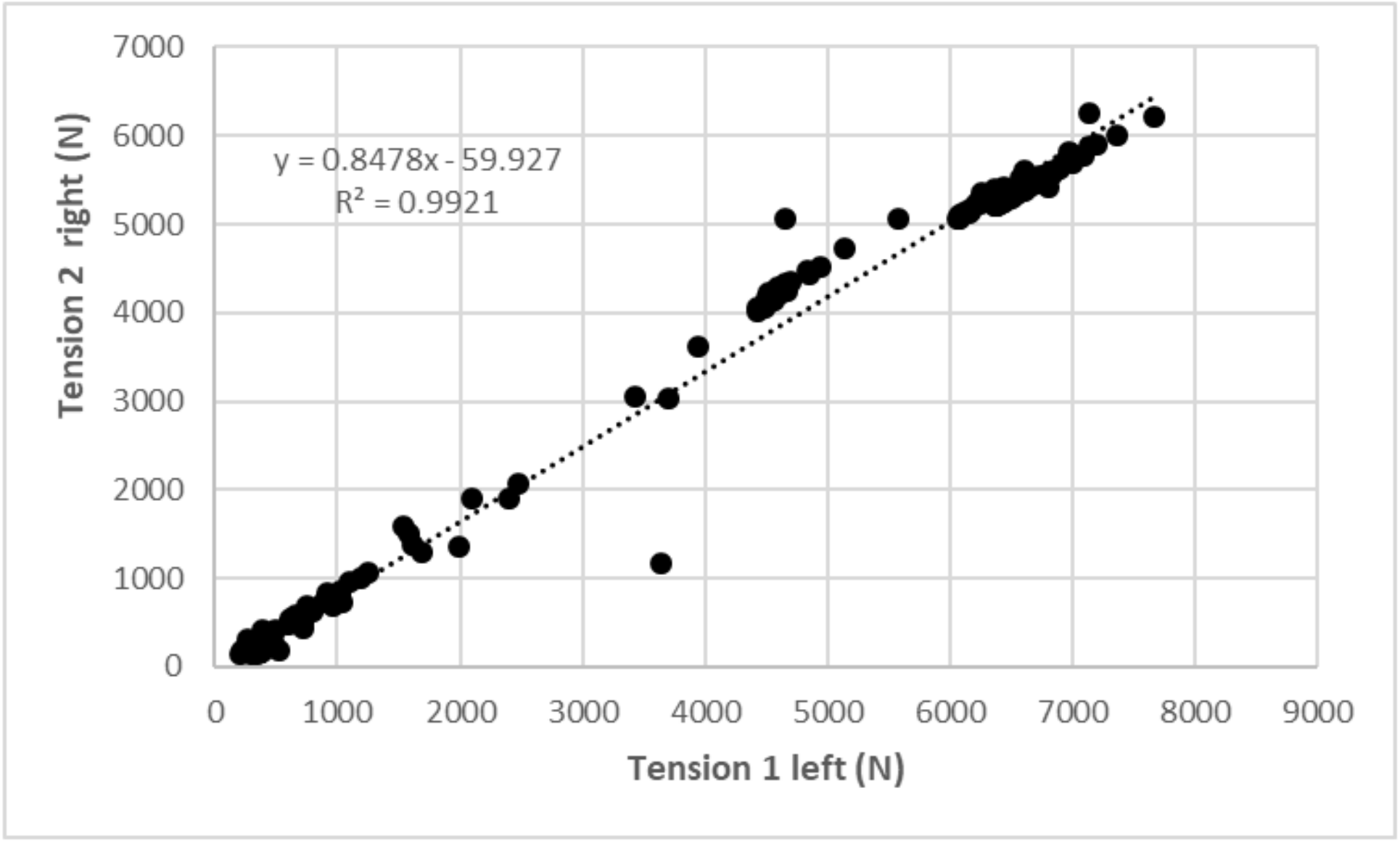
Design of continuous bridle multiple-stump anchors. 2019. International Journal of Forest Engineering. https://doi.org/10.1080/14942119.2020.1685833

C. Kevin Lyons, Associate Professor, Dept. of Forest Engineering, Resources and Management, Oregon State University, Corvallis, Oregon, USA 97331, kevin.lyons@oregonstate.edu

John Sessions, Professor, Dept. of Forest Engineering, Resources and Management, Oregon State University, Corvallis, Oregon, USA 97331, john.sessions@oregonstate.edu

Jeffrey Wimer, Instructor, Dept. of Forest Engineering, Resources and Management, Oregon State University, Corvallis, Oregon, USA 97331, Jeffrey.Wimer@oregonstate.edu


Skyline
Load cell 2
Y
Load cell 1
p5
To Anchor
block 1 (p_1)
To Anchor
block 2 (p_2)
To Anchor
block 3 (p_3)
X


y = 0.8478x - 59.927
R² = 0.9921
Tension 2 right (N)
Tension 1 left (N)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000

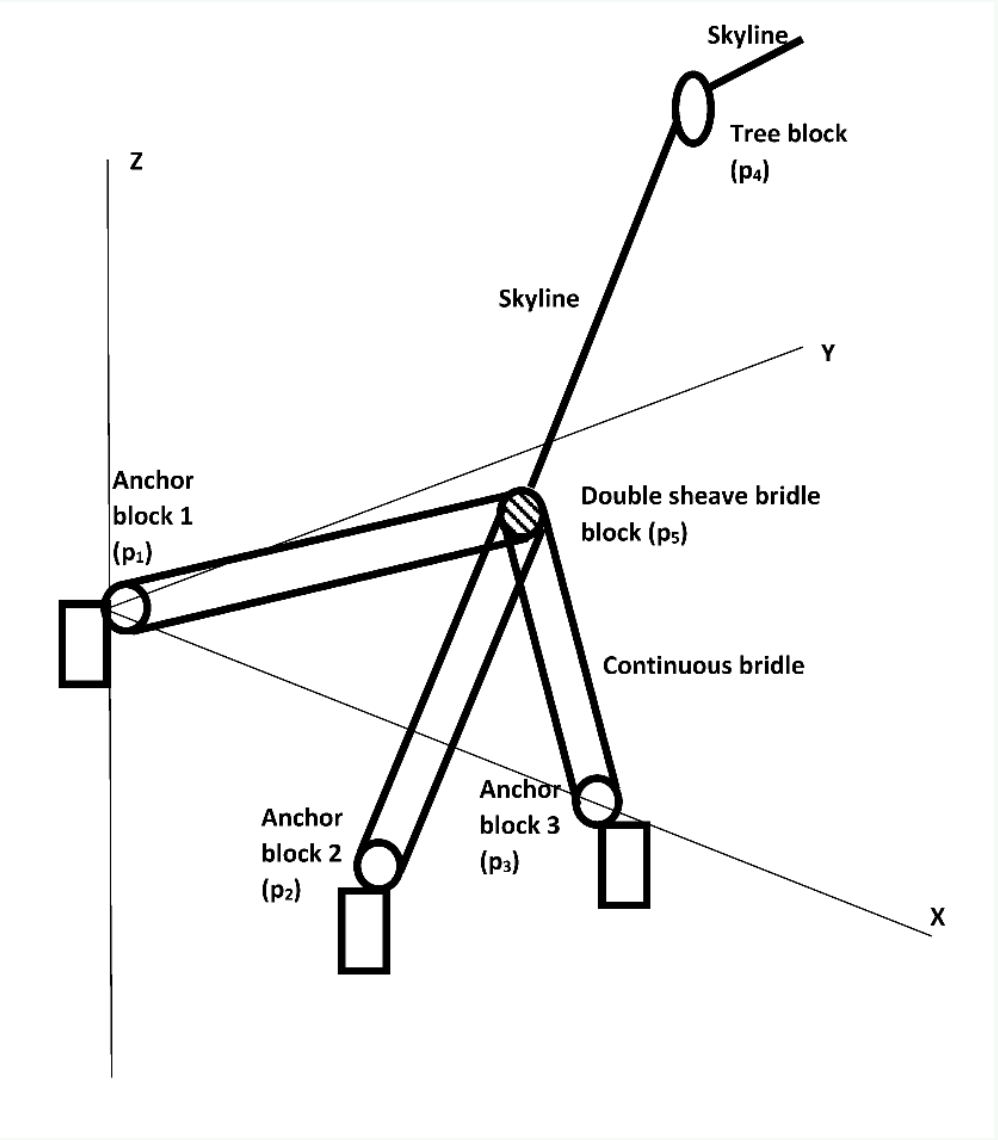
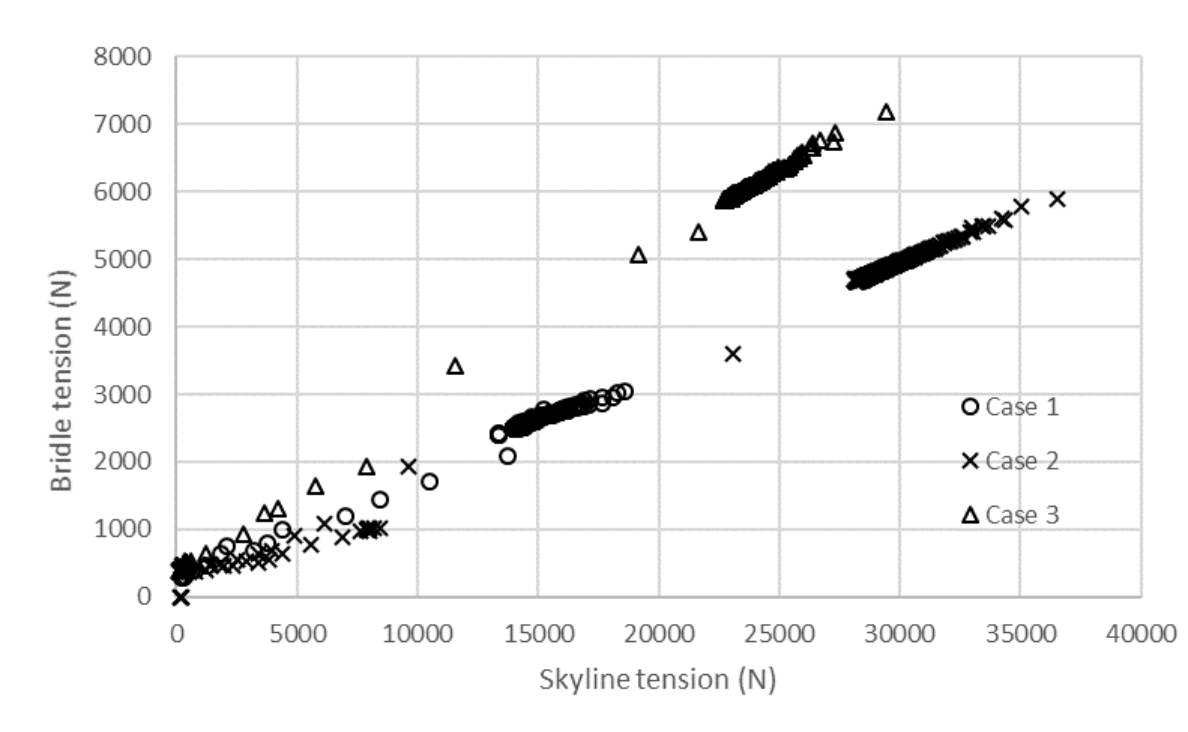
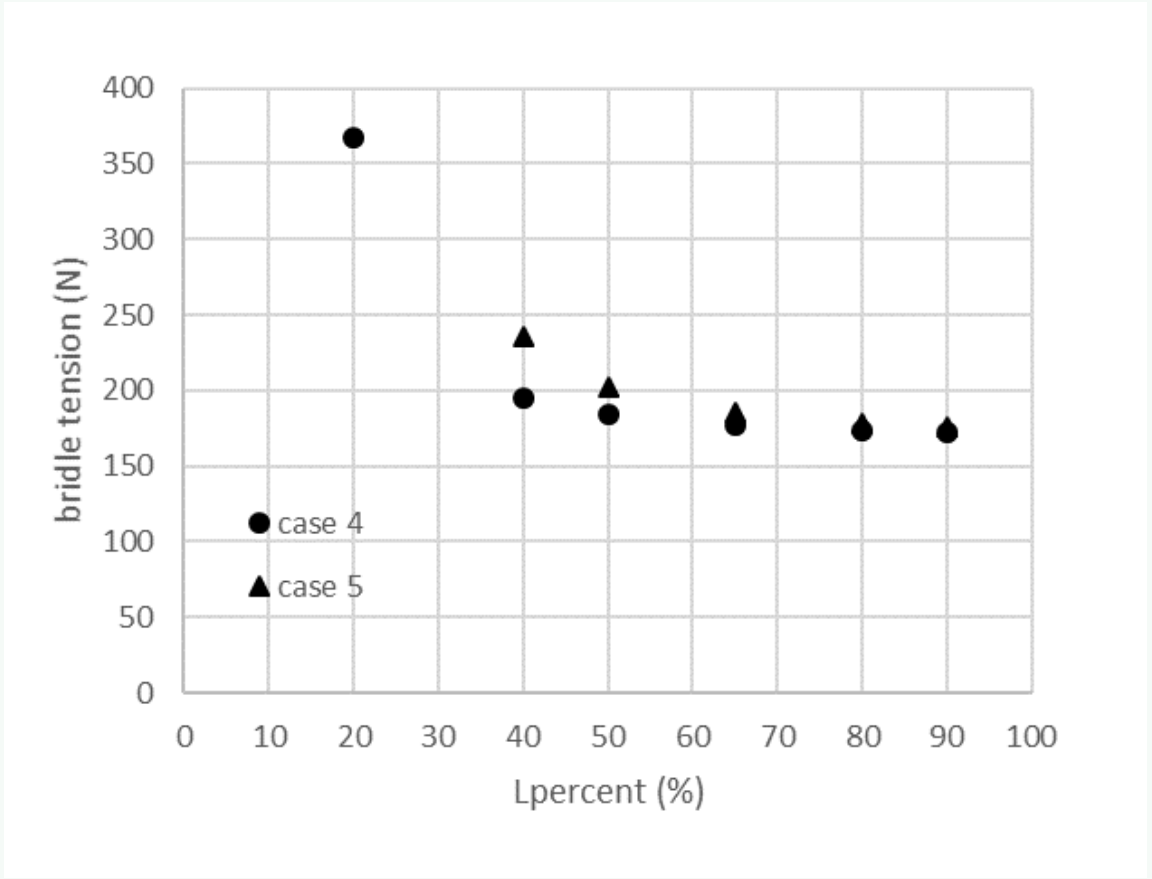


Table 1, Field tension measurements and comparison to model result.

Case 1, pull perpendicular to x with modest spread	**Measured Ts (N)**	**Measured T (N)**	**Modeled T (N)**
	17638	2953	3257
Case 2, pull in lead with x			
	33501	5484	6161
Case 3, pull perpendicular to x with wide spread			
	27340	6877	6523

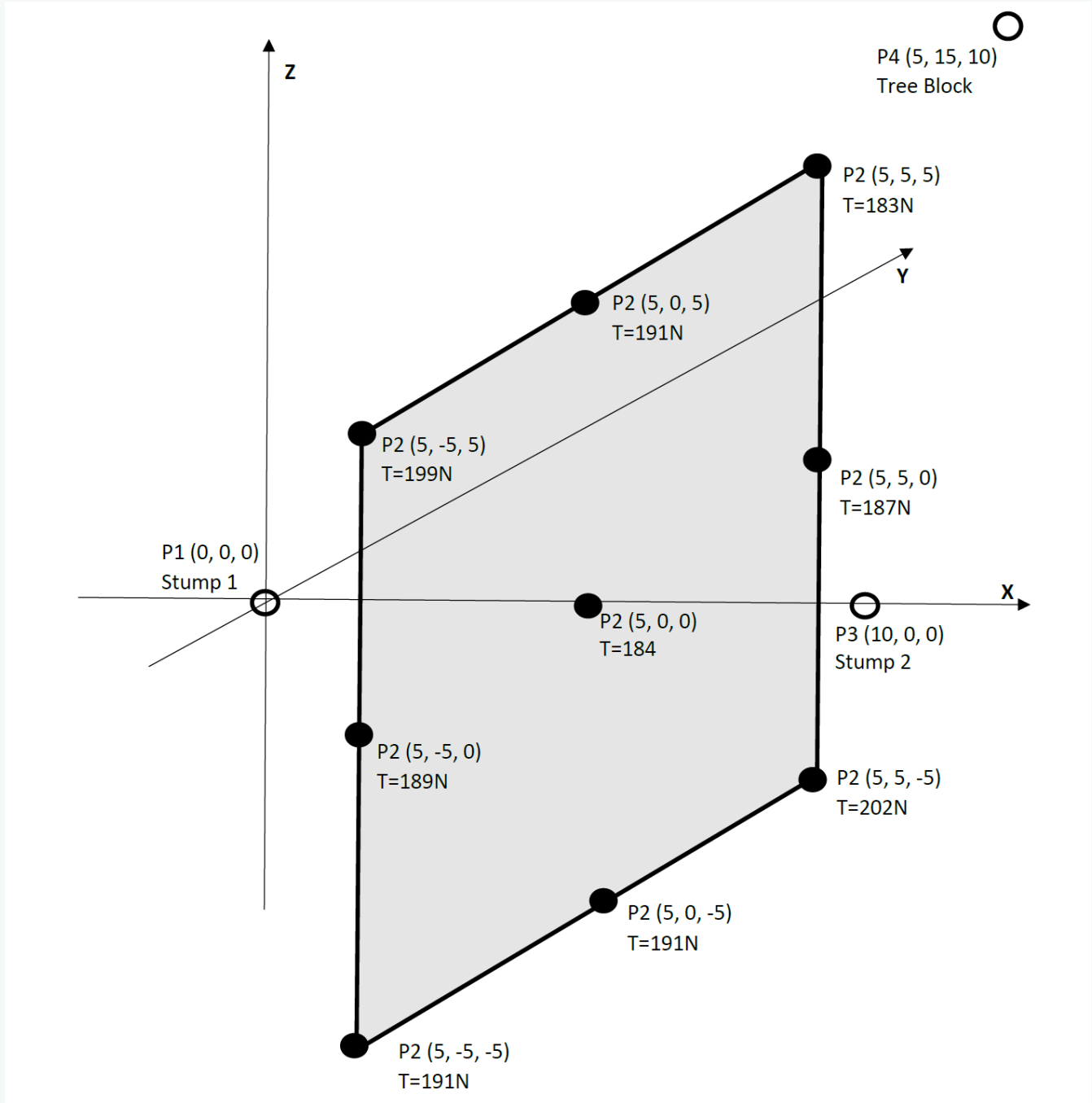


Case 1, pull perpendicular to x with modest spread	x1[a]	y1	z1
p_1	0.00	0.00	0.00
P_2	4.32	1.70	0.52
p_3	8.71	0.00	0.00
p_4	4.58	10.73	0.00
p_5	4.15	5.57	0.11
Case 2, pull in lead with x	**x2**	**y2**	**z2**
p_1	0.00	0.00	0.00
P_2	5.07	1.59	0.56
p_3	9.38	0.00	0.00
p_4	-11.93	13.08	0.00
p_5	-1.91	4.33	0.36
Case 3, pull perpendicular to x with wide spread	**x3**	**y3**	**z3**
p_1	0.00	0.00	0.00
P_2	1.39	-5.15	0.58
p_3	10.92	0.00	0.00
p_4	4.81	18.86	0.00
p_5	3.65	5.16	0.54



$$L = \frac{Lpercent}{100\%} * 2 \sum_{1}^{3} |\mathbf{p}_k - \mathbf{p}_4|$$

Two cases for the anchor stumps were selected to examine the effect of *Lpercent* on *T*.
Case 4: $\mathbf{p}_1 = (0,0,0)$, $\mathbf{p}_2 = (5,0,0)$, $\mathbf{p}_3 = (10,0,0)$, $\mathbf{p}_4 = (5,15,10)$
Case 5, $\mathbf{p}_1 = (0,0,0)$, $\mathbf{p}_2 = (5,5,-5)$, $\mathbf{p}_3 = (10,0,0)$, $\mathbf{p}_4 = (5,15,10)$,



Bridle tension (T) given varying positions for $\mathbf{p}_2$.

The skyline tension is 1000N and $Lpercent = 50\%$.

For $\mathbf{p}_2 = (5,0,0)$ the location of $\mathbf{p}_5 = (5,6.9,4.6)$.

Summary

- Trilateration effective for stump location
- Swarm solution functional for equilibrium solution
- Assumption of frictionless pulleys valid when using blocks with bearings
- Spread of the outside stumps is the determining factor for bridle tension
- Bridle length given anchor and tree block locations is preferably greater than 50%
- More design and testing is required for the nylon bobbins.