Tree Support Systems

Don Roppolo
Davey / The Care of Trees

Tree Support and Protection

- Why install support systems
- Standards for support systems
- Types of support systems
- Installation practices and common mistakes

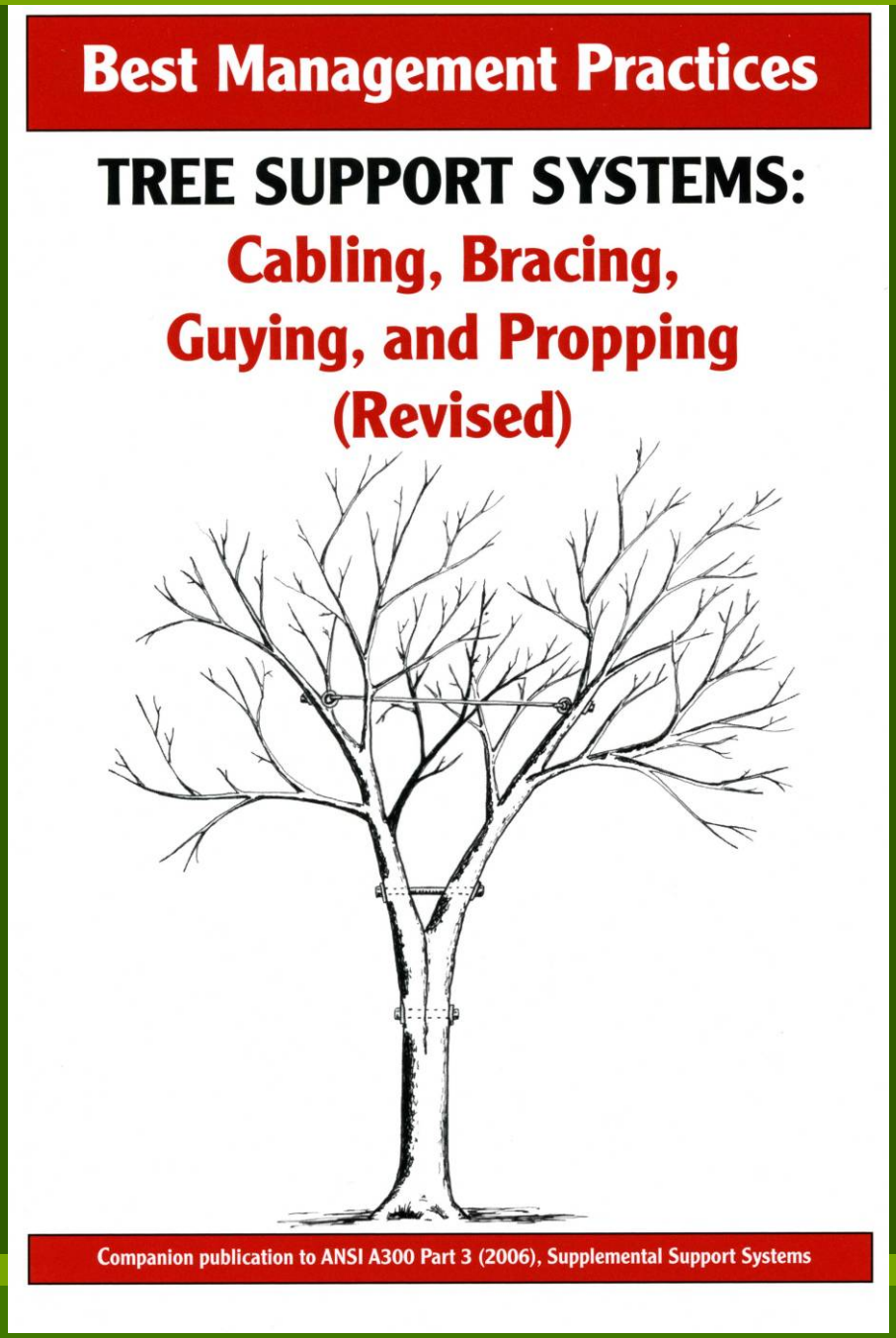
Why do we install support systems?

Image by Torrey Young

Top Three reasons to cable

- Weak branch unions
  - Codominant stems
  - Included bark
- Long, heavy limbs
- Supporting entire trees
  - guying

Supplemental Support Systems



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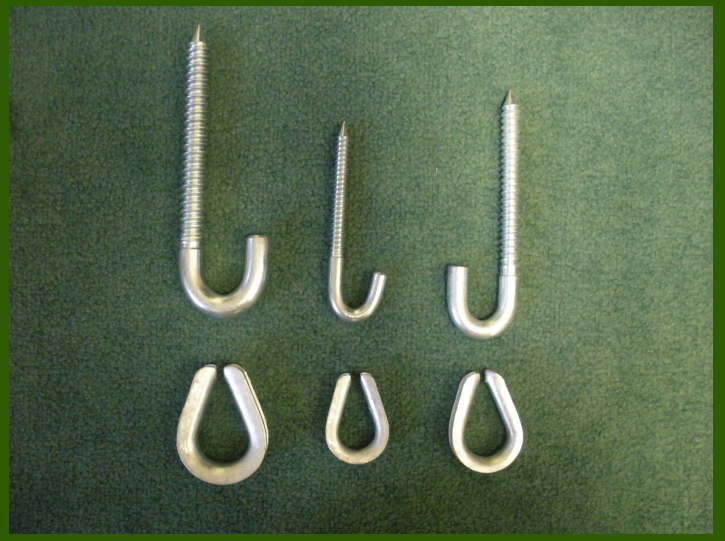
Tree Support



- Cables, bracing, guying, and lightning protection are all forms of hardware
- Hardware installation causes wounds and the risk of decay
- Hardware provide extra support by limiting movement of limbs they do not make trees “safe”
  - May reduce the risk of failure and extend tree life
  - Hazardous trees can not be made safe by use of cables

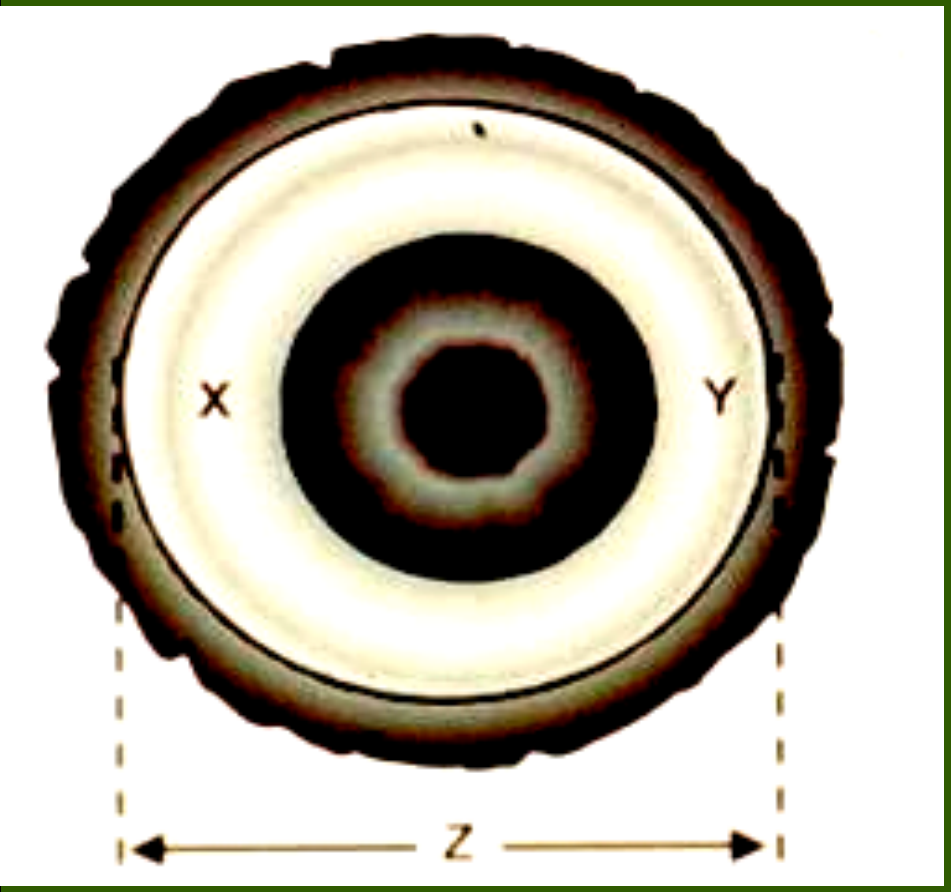
Cabling

- Cables are installed to
  - Support limbs that have weak branch unions like codominant stems
  - Support heavy limbs
  - Support weak wooded species
  - Support limbs that may pose a threat to people or property
  - Support whole trees

Cabling

- Before installing cables
  - Objectives for support systems need to be defined
  - Tree owner should be notified of the need for inspection
  - Tree must be thoroughly inspected
  - Have hazardous limbs pruned
  - Be properly pruned

Limbs or trees with less than 30% sound wood should be considered for removal



- X = sound wood depth, working side
- Y = sound wood depth, opposite side
- Z= Total diameter of the limb or trunk bark diameter not included
- Equation for percent of sound wood for through-bolt applications:
  [(X + Y) / Z] x 100 = % of sound wood for through-bolt applications

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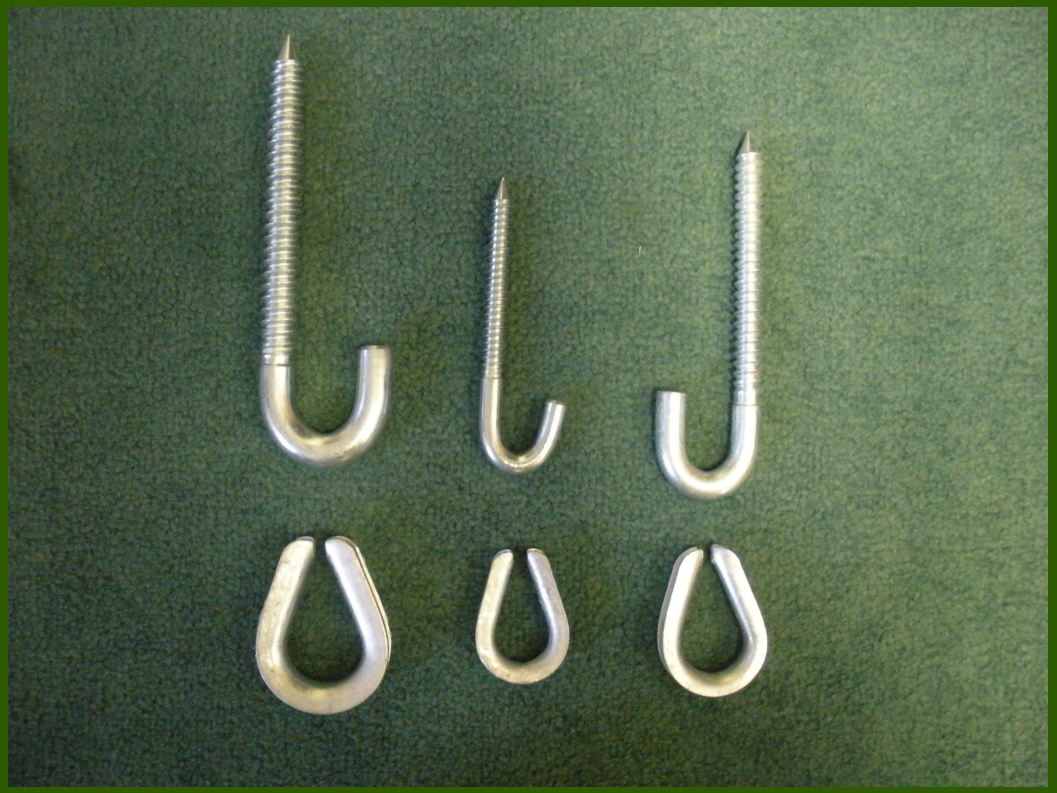
Cabling Hardware

- Factors that determine hardware selection
  - Estimated weight of the limb to be supported
  - Diameter of stem a point of installation
  - Presence of decay
  - Species and its ability to compartmentalize

Hardware



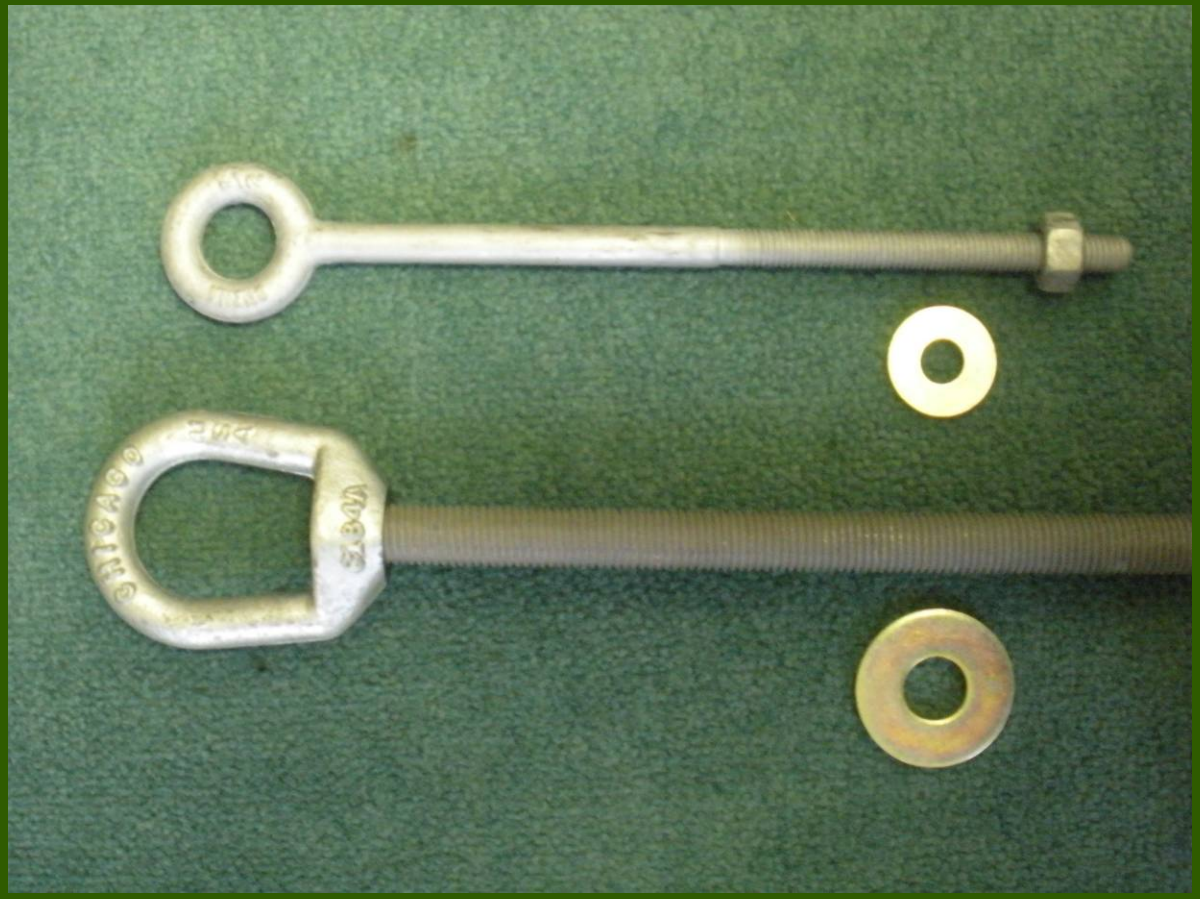
- Dead-end hardware
  - Lag hook (“J” Lag or J-hook)

Dead-end hardware

- Strength comes from threads against wood
- Holes must be 1/16” to 1/8” smaller than hardware
- Should never be placed in decayed wood
- For limbs less than 10” diameter

Dead-end hardware
Threads must be fully seated

Hardware



- Through-Hardware
  - Eye bolts
  - Threaded rods
  - Amon-eye

Through-Hardware

- Good for limbs over 10” diameter
- Strength comes from tension against wood
- Holes may be drilled up to 1/8” larger than hardware
- Good for decayed limbs
- Washers must be used under nuts, and be seated
- Good for angled installation

Through-Hardware
cut excess and secure
peen threads or jam nut

Minimum Hardware Requirements for Cabling

Table 4. Minimum hardware size requirements for cabling trees (adapted from ANSI A300 Part 3, Table A-1).

Max. branch diameter at point of attachment in inches	Est. load in pounds	Lag-hook diameter in inches	Eye-bolt diameter in inches	Amon-eye threaded rod diameter in inches	Common-grade cable diameter in inches	Extra-high-strength cable diameter in inches	Aircraft-cable diameter in inches
2	100	1/4	1/4	1/4	1/8	3/16	1/8
3.5	200	5/16	1/4	1/4	3/16	3/16	1/8
5	300	3/8	1/4	1/4	1/4	3/16	1/8
8	600	1/2	5/16	5/16	5/16	3/16	3/16
10	900	5/8	3/8	3/8	3/8	1/4	1/4
15	1000	NA	3/8	3/8	7/16	1/4	1/4
[illegible]	1200	NA	3/8	3/8	1/2	1/4	1/4
20	1400	NA	1/2	1/2	1/2	5/16	1/4
24	2200	NA	1/2	1/2	NA	5/16	3/8
28	3300	NA	5/8	5/8	NA	7/16	1/2
30	3700	NA	NA	7/8	NA	7/16	1/2

*Indicates that the application is not acceptable.
1 inch = 2.54 cm

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Hardware Working Loads

Table 2. Approximate working-load limit (WLL)* of various components in tree support systems (in pounds).

Hardware diameter in inches	Eye bolts	Lag hooks	Amon-eye nuts	Common galvanized cable	EHS cable	Aircraft cable	Poly-propylene rope†	Polyester HMWPe‡	Turn-buckles	Compression springs
1/8				108		400				
3/16				230	798	840				
1/4	550	100	520	380	1330	1400				
5/16	850	200	840	640	2240	1960				890
3/8	1250	300	1240	850	3080	2880	220	(10/5) 1000	1040	1247
								(10/20) 4000		
7/16			1700	1140	4160	3900				1620
1/2	2250	600	2400	1480	5380	5000	880	(13/11) 2200	1960	2020
9/16						8000				
5/8	3600	900	3600				1760		3160	
7/8	7200		7200							

*Working-load limit is defined as the breaking strength, as determined by the manufacturer, divided by a design factor. For this table, the design factor was assumed 5:1, or 20 percent, of the breaking strength.
†Cobra is constructed of polypropylene rope.
‡TreeSave is constructed of polyester or high-molecular-weight polyester (HMWPe) with or without a core. Shown in parentheses are TreeSave diameter (given in millimeters) and tensile strength (in 1000 pounds).
1 inch = 2.54 cm

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Green Log Weight Chart

Diameters from 14 inches to 49 inches

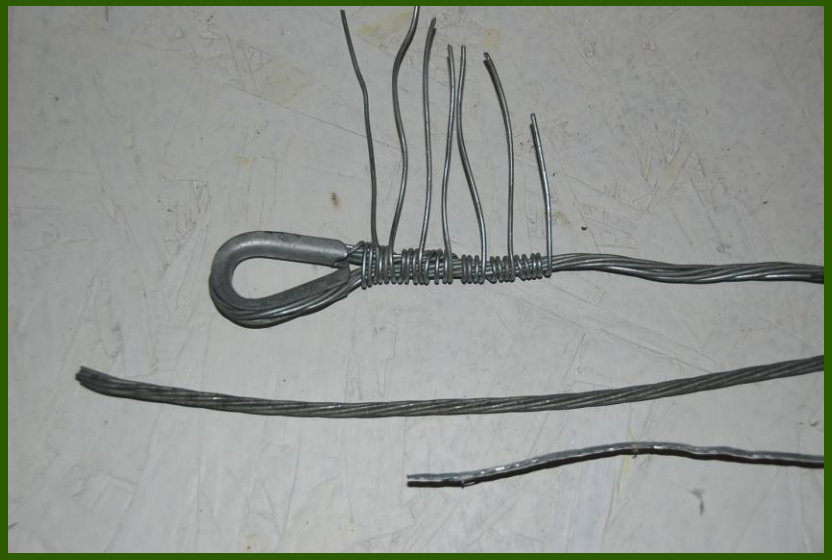
larger sizes continued on back

Courtesy of Mark Adams, Certified Arborist and Certified Treecare Safety Professional (CTSP)

Species	Dia. In inches → / Weight per cubic foot ↓	14	16	18	20	22	24	26	28
		Weight in Pounds, of One Foot Sec							
Alder, red	46	49	64	81	100	121	145	170	197
Apple	55	59	77	97	120	145	173	203	235
Ash, green	47	50	66	83	103	124	148	173	201
Ash, Oregon	48	51	67	85	105	127	151	177	205
Ash, white	48	51	67	85	105	127	151	177	205
Aspen, quaking	43	46	60	76	94	114	135	159	184
Baldcypress	51	55	71	90	111	135	160	188	218
Basswood	42	45	59	74	92	111	132	155	180
Beech	54	58	75	95	118	143	170	199	231
Birch, paper	50	53	70	88	109	132	157	184	214
Birch, yellow	57	61	80	101	124	150	179	210	244
Butternut	46	49	64	81	100	121	145	170	197
Cedar, incense	45	48	63	80	98	119	141	166	192
Cedar, western red	28	30	39	49	61	74	88	103	120
Cherry, black	45	48	63	80	98	119	141	166	192
Chestnut	55	59	77	97	120	145	173	203	235
Chinaberry	50	53	70	88	109	132	157	184	214
Cottonwood	49	52	68	87	107	129	154	181	210
Elm, American	54	58	75	95	118	143	170	199	231
Fir, Douglas	39	42	54	69	85	103	123	144	167
Fir, noble	29	31	40	51	63	77	91	107	124
Fir, white	47	50	66	83	103	124	148	173	201
Gum, black	45	48	63	80	98	119	141	166	192
Gum, red	50	53	70	88	109	132	157	184	214
Hackberry	50	53	70	88	109	132	157	184	214
Hemlock, eastern	49	52	68	87	107	129	154	181	210
Hemlock, western	41	44	57	72	89	108	129	151	175
Hickory, Shagbark	64	68	89	113	140	169	201	236	274
Honeylocust	63	67	88	111	137	166	198	232	269
Horsechestnut	41	44	57	72	89	108	129	151	175
Larch	51	55	71	90	111	135	160	188	218
Locust, black	58	62	81	102	127	153	182	214	248
Locust, honey	61	65	85	108	133	161	192	225	261
Magnolia, ev.	59	63	82	104	129	156	185	218	252
Maple, red	50	53	70	88	109	132	157	184	214
Maple, silver	45	48	63	80	98	119	141	166	192
Maple, sugar	56	60	78	99	122	148	176	206	239
Oak, black	62	66	87	110	135	164	195	229	265
Oak, Cali. black	66	71	92	117	144	174	207	243	282
Oak, English	52	56	73	92	113	137	163	192	222
Oak, live	76	81	106	134	166	201	239	280	325
Oak, pin	64	68	89	113	140	169	201	236	274
Oak, post	63	67	88	111	137	166	198	232	269
Oak, red	63	67	88	111	137	166	198	232	269
Oak, scarlet	64	68	89	113	140	169	201	236	274
Oak, white	62	66	87	110	135	164	195	229	265
Osage orange	62	66	87	110	135	164	195	229	265
Pecan	61	65	85	108	133	161	192	225	261
Persimmon	63	67	88	111	137	166	198	232	269
Pine, loblolly	53	57	74	94	116	140	167	195	227
Pine, lodgepole	39	42	54	69	85	103	123	144	167
Pine, longleaf	55	59	77	97	120	145	173	203	235
Pine, ponderosa	46	49	64	81	100	121	145	170	197
Pine, slash	58	62	81	102	127	153	182	214	248
Pine, sugar	52	56	73	92	113	137	163	192	222
Pine, white	36	38	50	64	79	95	113	133	154
Poplar, yellow	38	41	53	67	83	100	119	140	162
Redwood, coastal	50	53	70	88	109	132	157	184	214
Sassafras	44	47	61	78	96	116	138	162	188
Spruce, Red	34	36	47	60	74	90	107	125	145
Spruce, sitka	32	34	45	57	70	84	101	118	137
Sweetgum	55	59	77	97	120	145	173	203	235
Sycamore	52	56	73	92	113	137	163	192	222
Tamarack	47	50	66	83	103	124	148	173	201
Walnut, black	58	62	81	102	127	153	182	214	248
Willow	32	34	45	57	70	84	101	118	137

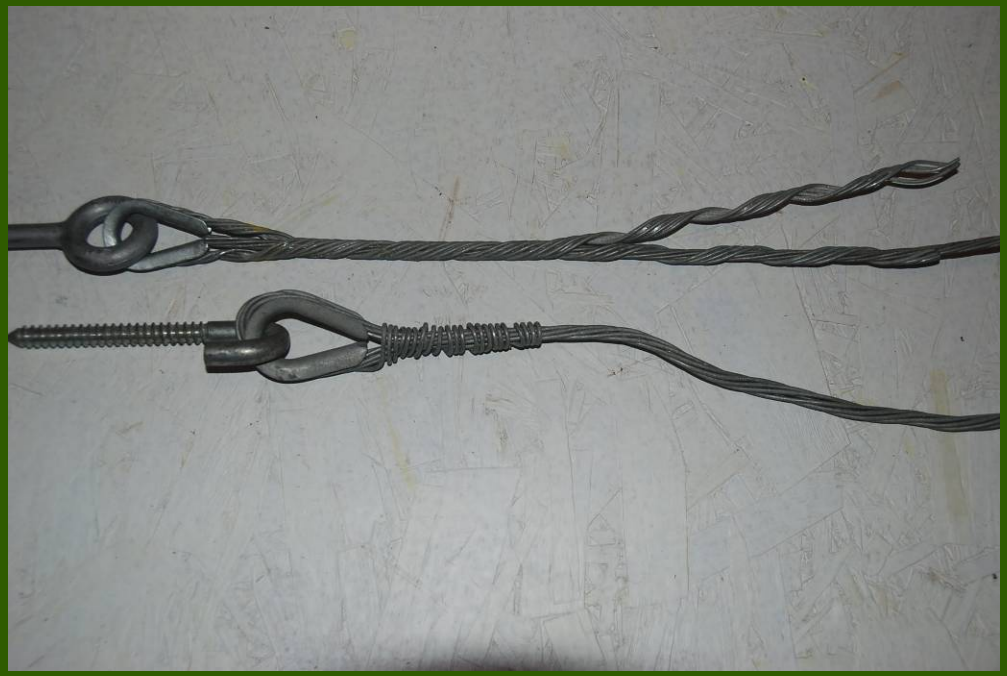
TCIA
VOICE OF TREE CARE
TREE CARE INDUSTRY ASSOCIATION
136 Harvey Road, Suite 101,
Londonderry, NH 03053
Phone (603) 314-5380
Fax (603) 314-5386
E-mail: info@tcia.org
www.tcia.org

Hardware



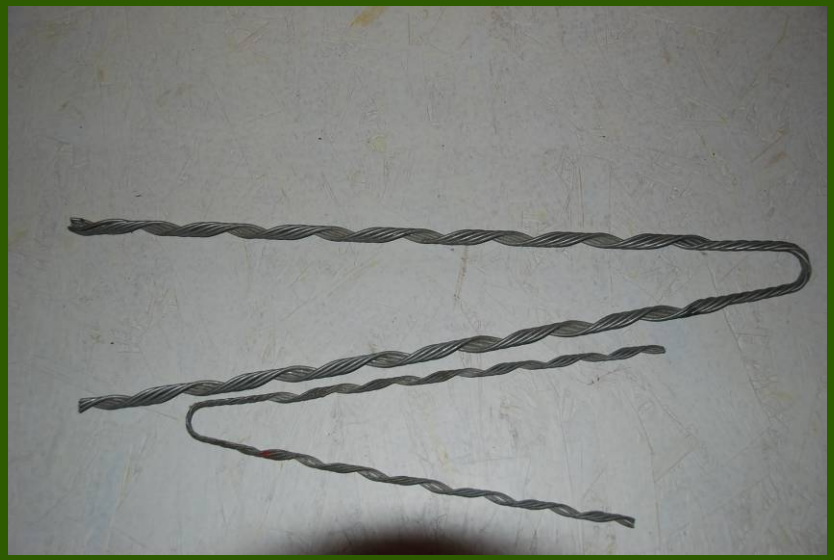
- Static cable systems
  - 7 strand Common grade also know as soft lay
    - Low strength ¼” 1,900 lbs
    - Soft and easily spliceable (good for tight applications
  - EHS (Extra High Strength)
    - Very strong ¼” 6,650 lbs
    - Stiff not splicable
  - light duty cable
    - Often used in small tree / weight support applications

Hardware



- Thimbles – must be used at the connection of any cable to an anchor
  - Increases bend radius
  - Reduces wear and extends life of cable
  - Must use appropriate size
  - Must be heavy-duty

Hardware



- Dead-End Grips (quick ends) used mainly to attach EHS cable to anchor hardware

Tools and Equipment

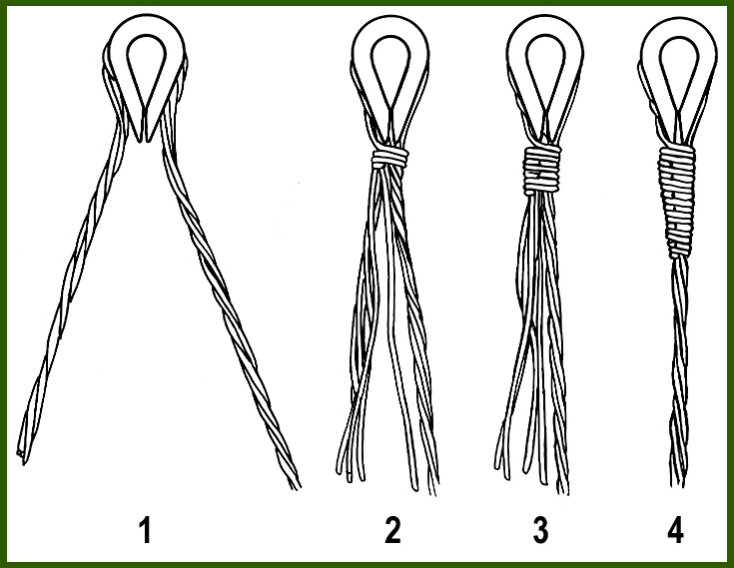
- Come-along – winch like device used to tighten cables or bring limbs together
- Cable grip (havens grip)– device used to attach the come-along to the cable

Tools and Equipment

Cable aid – tool used mainly to tighten lags

Ship auger – type of drill bit that is self feeding and efficient at extracting shavings

Cable Installation



- Eye splice – eye formed by individually wrapping strands around the cable,
  - Used to attach common grade cable to anchor

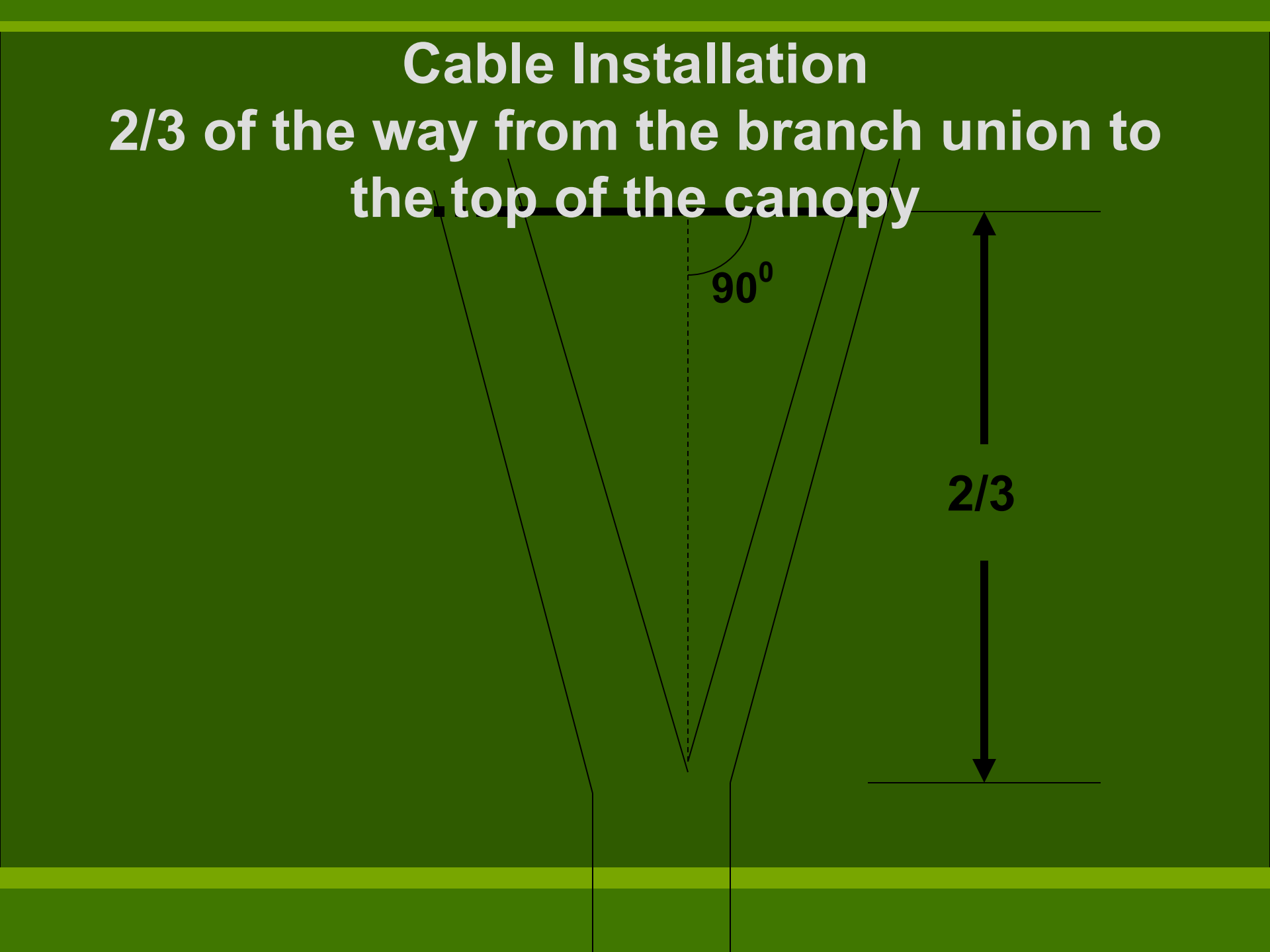
Cable Installation

- Cable clamps
  - Used to attach cables of 1/8” or smaller to anchor hardware
  - Should use at least 3 per anchor spaced apart
  - The “U” of the clamp goes on the short end of cable

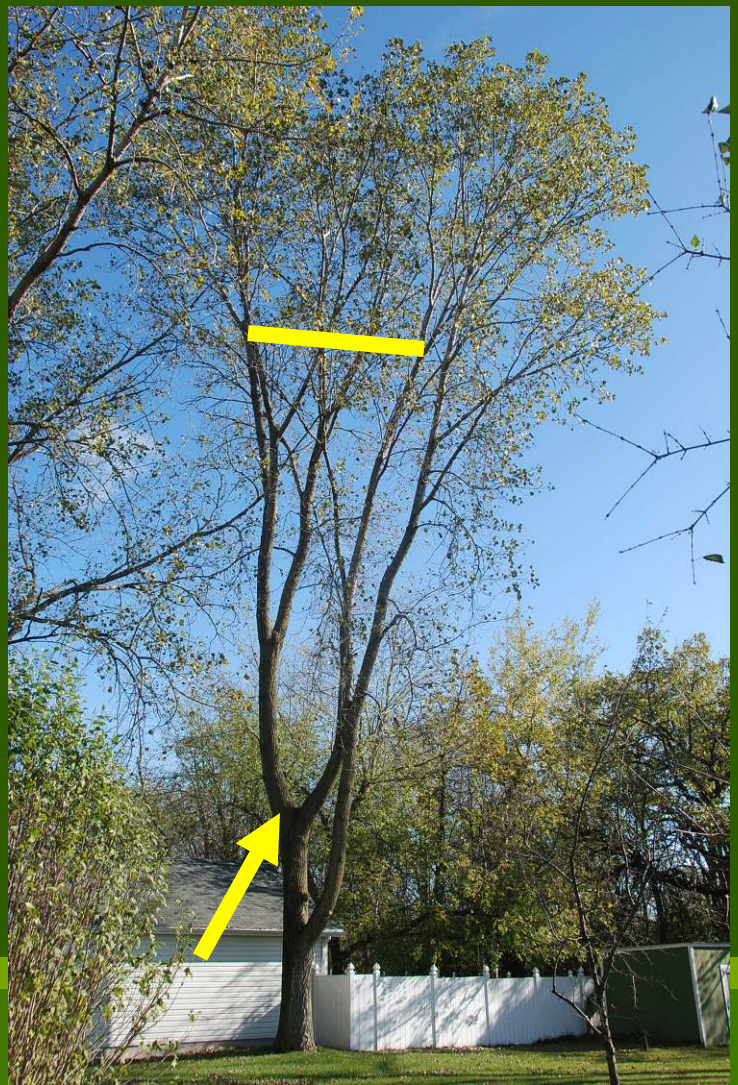
Wire Stop

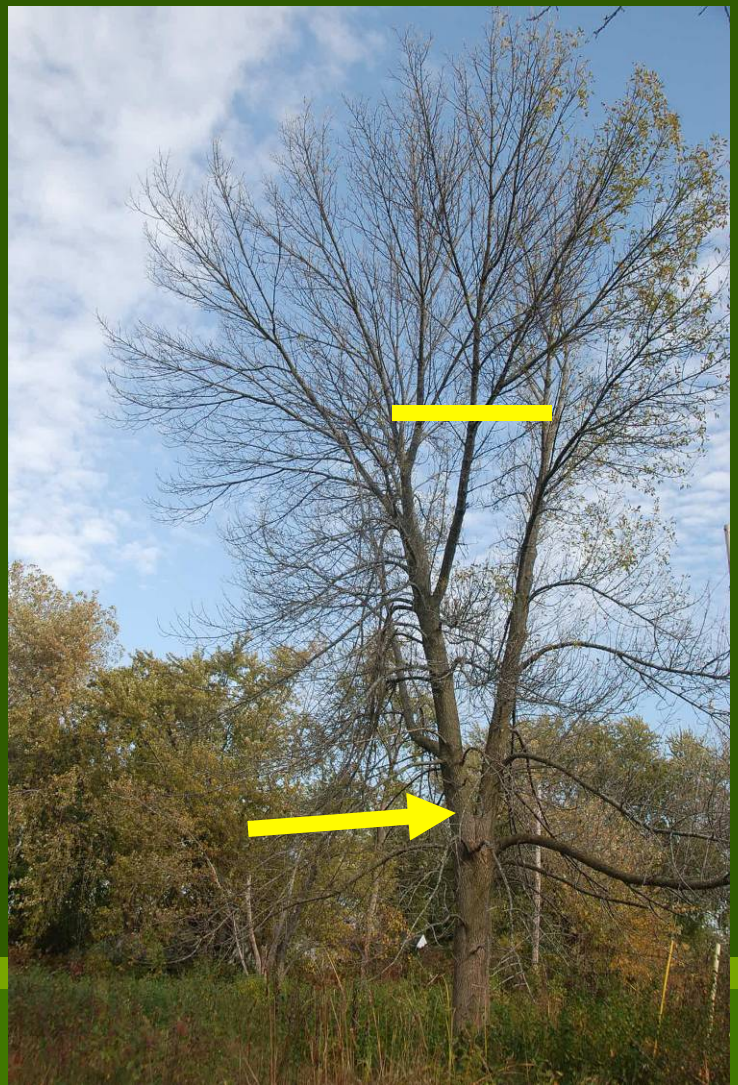
Wedge Grip

Cable Installation
2/3 of the way from the branch union to the top of the canopy

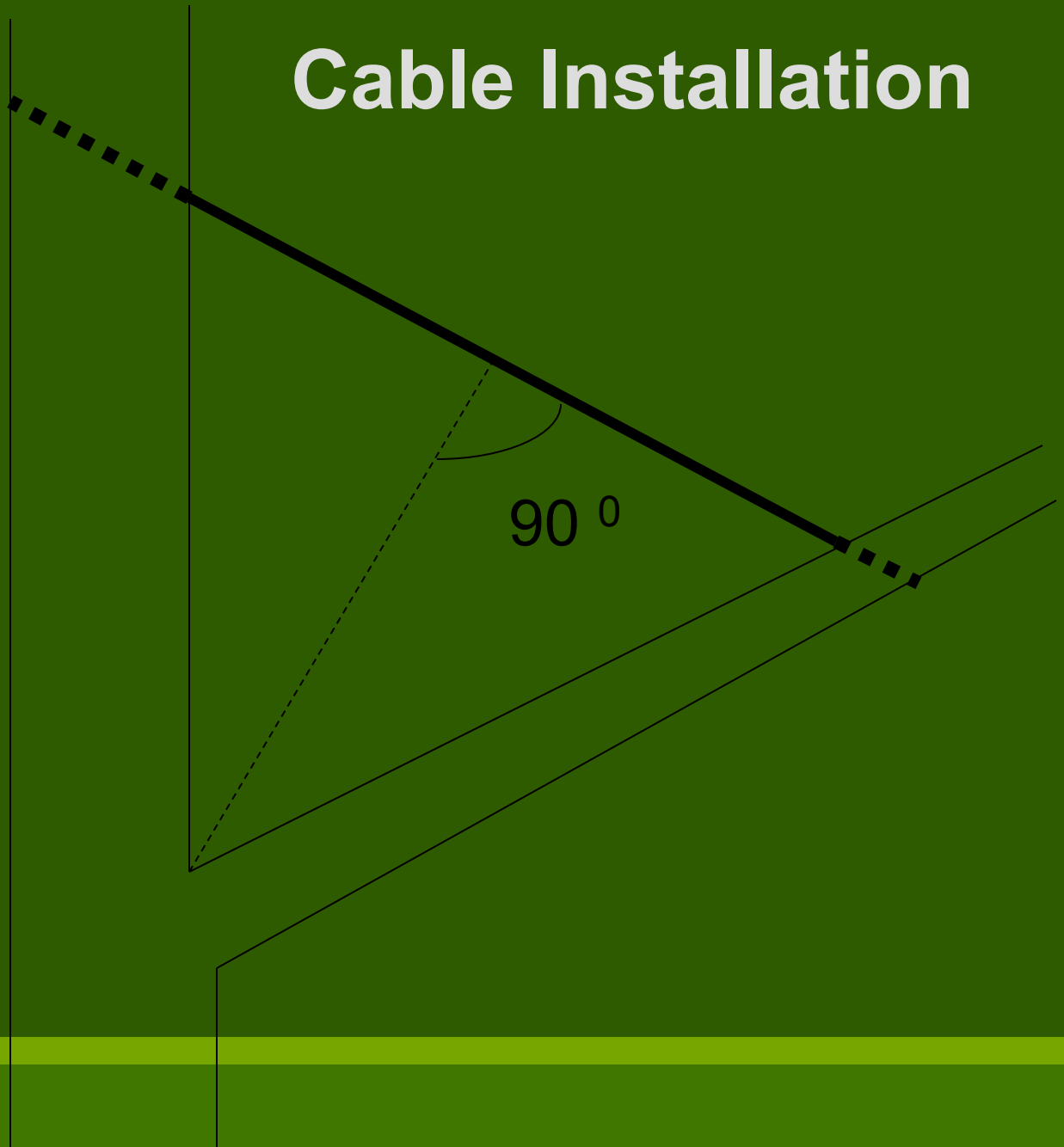


Cable Installation
2/3 of the way from the branch union to the top of the canopy

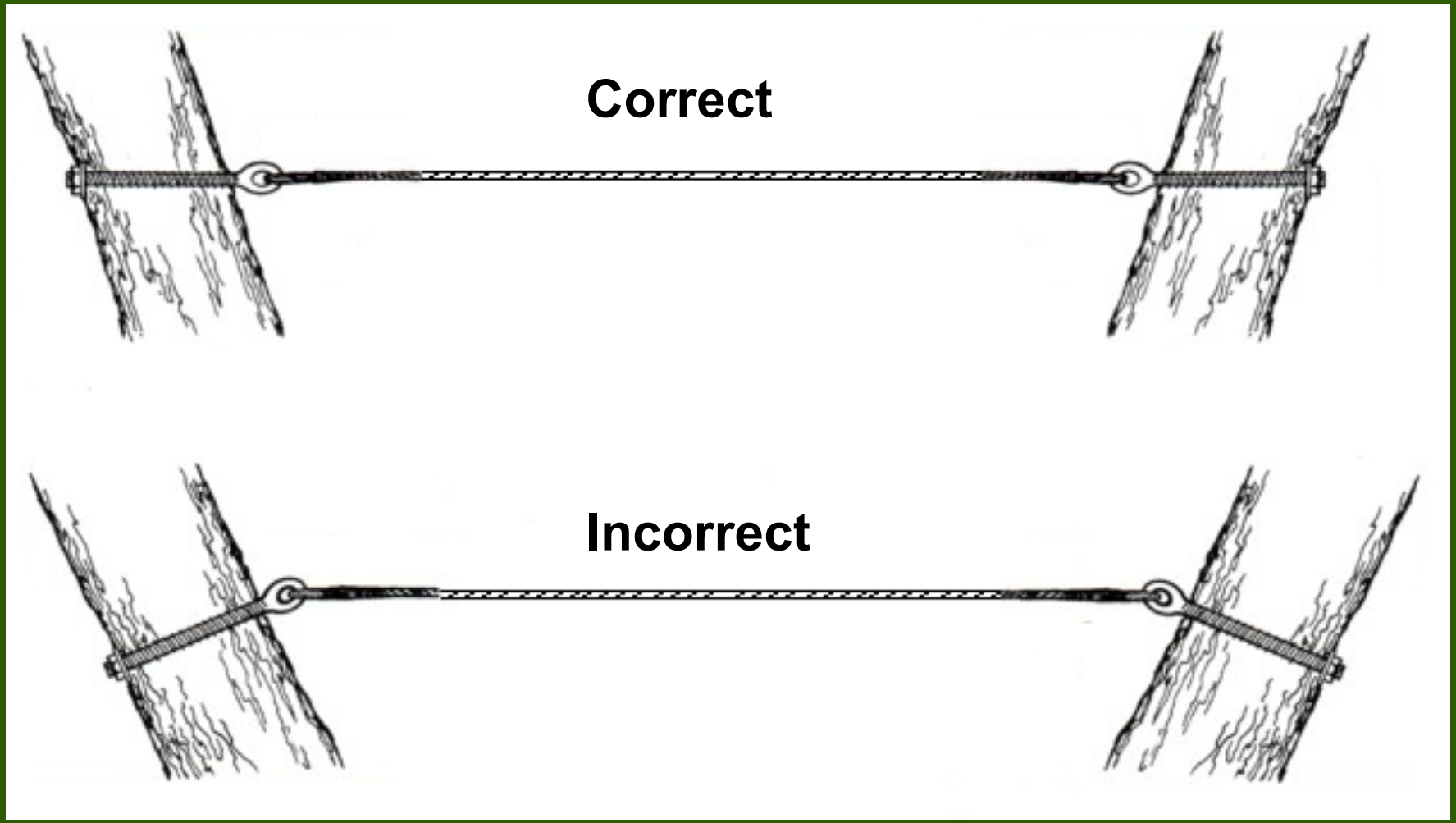




Cable Installation



Anchor Hardware alignment

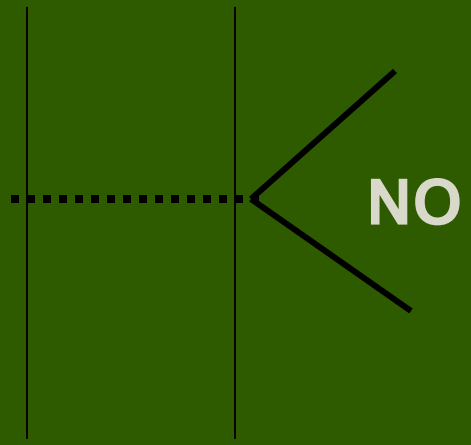


Cable Installation

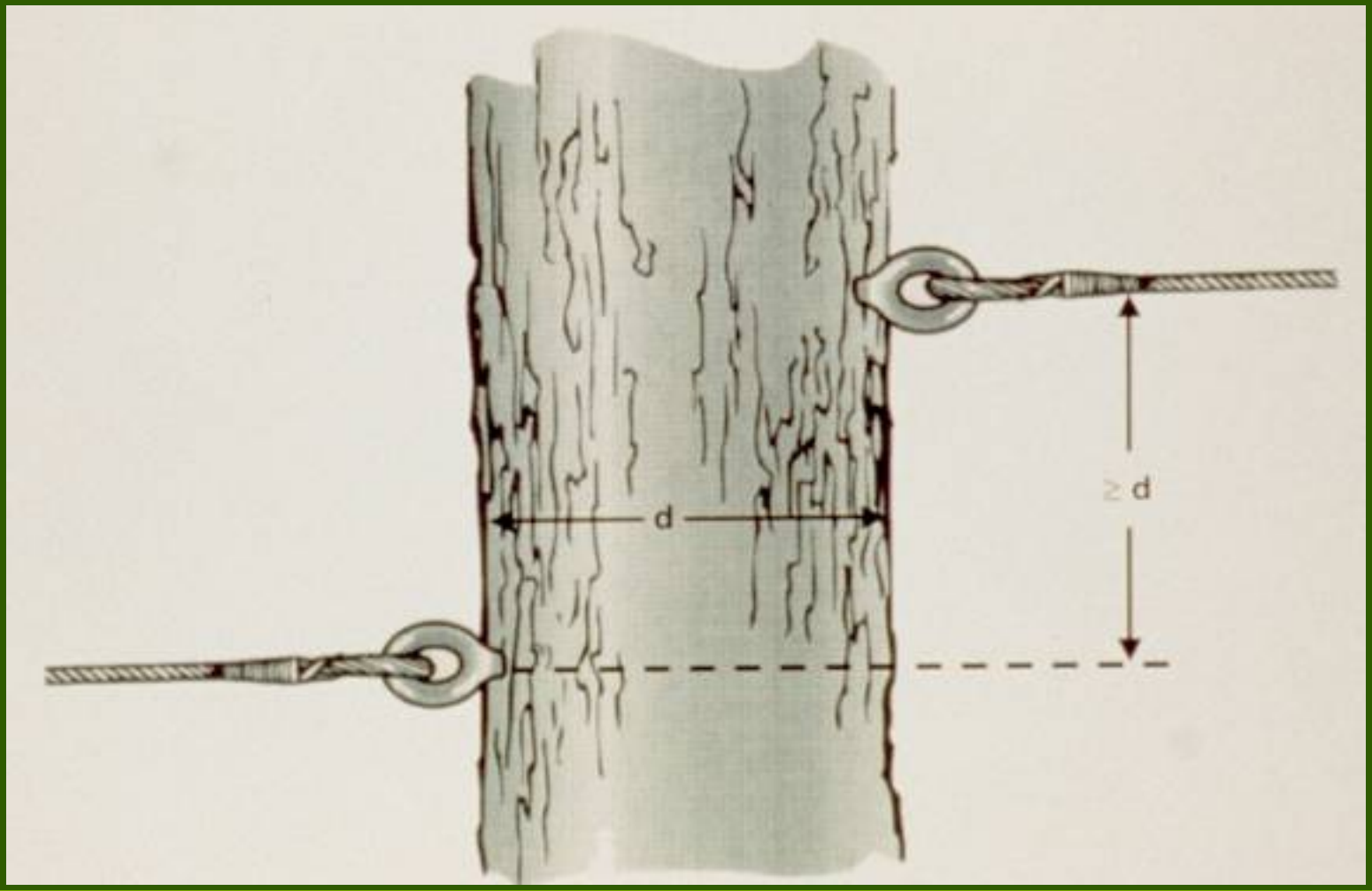
Anchor hardware must be installed in alignment with the angle the cable will be installed

Cable Installation

Only one cable per anchor



Anchors must be at least one diameter apart

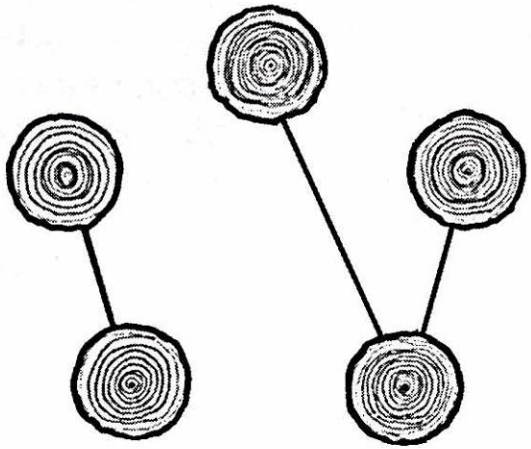


Cable Installation tension

Taut

Cable Installation

a. Direct. Direct cabling consists of a single cable between two tree parts, e.g., two limbs, two stems, or a trunk and a limb (three direct cables shown).



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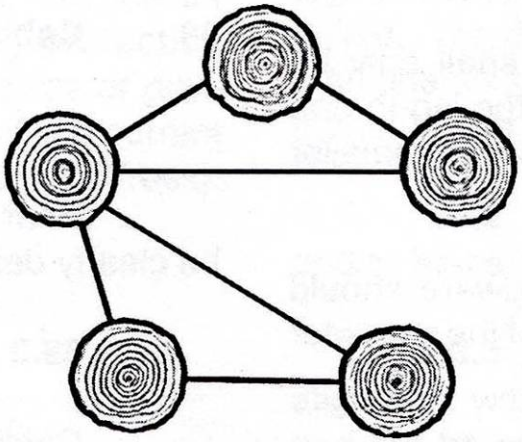
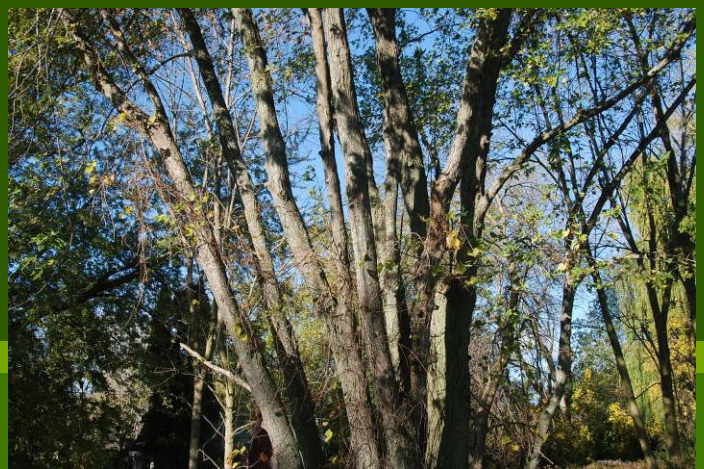
Triangular System

b. Triangular. Triangular cabling consists of connecting tree parts in combination of threes. This method should be preferred, when maximum support is required (two triangular systems shown).





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Cable Instalation

- Lightning protection systems in a tree must be bonded to any support cables installed in the same tree

Dynamic cable Systems

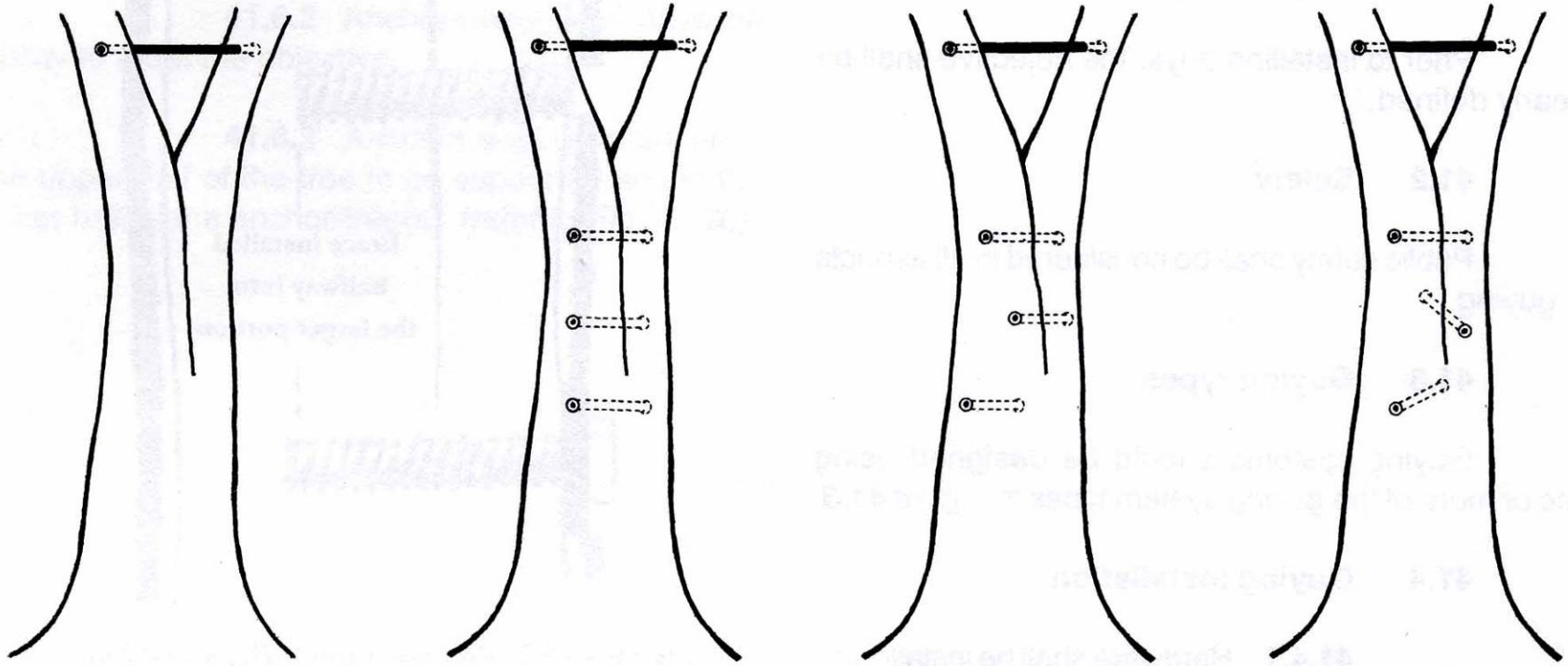
- Support systems mainly maid of synthetic rope
- Some incorporate rubber shock absorbers
- Some have installation process that do not wound the tree with anchor hardware

Dynamic cable Systems

Image by Ed Hayes

Figure 40.2 - Bracing system types

Bracing systems should be designed using one or more of the following types:



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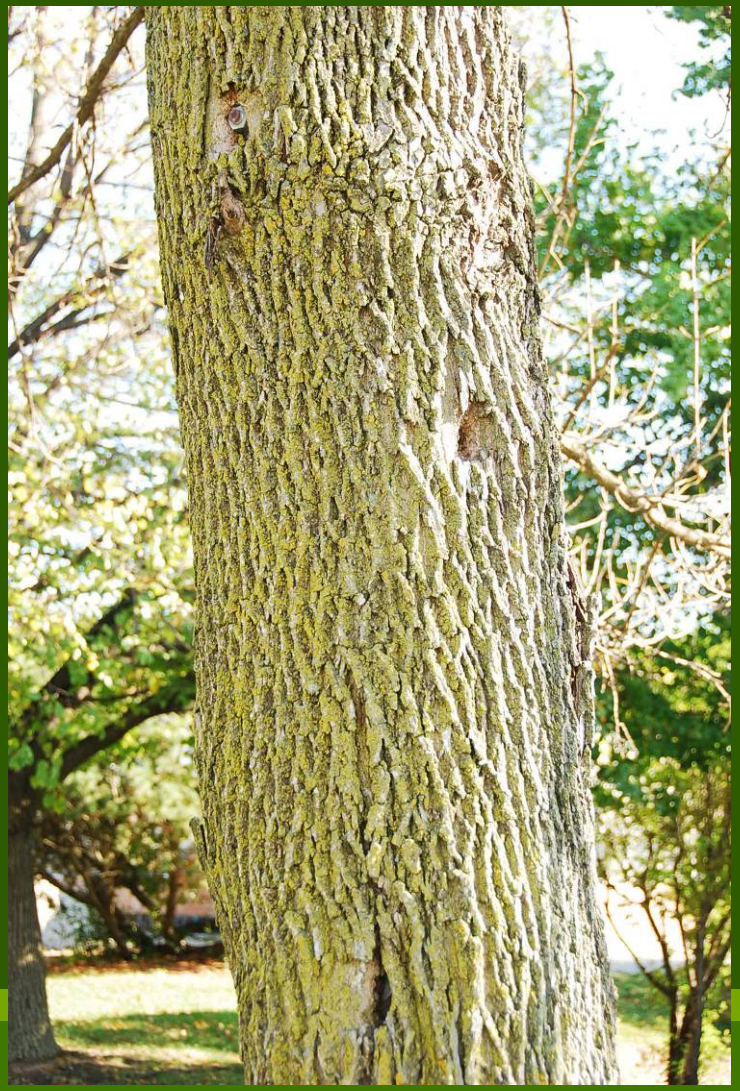

Bracing

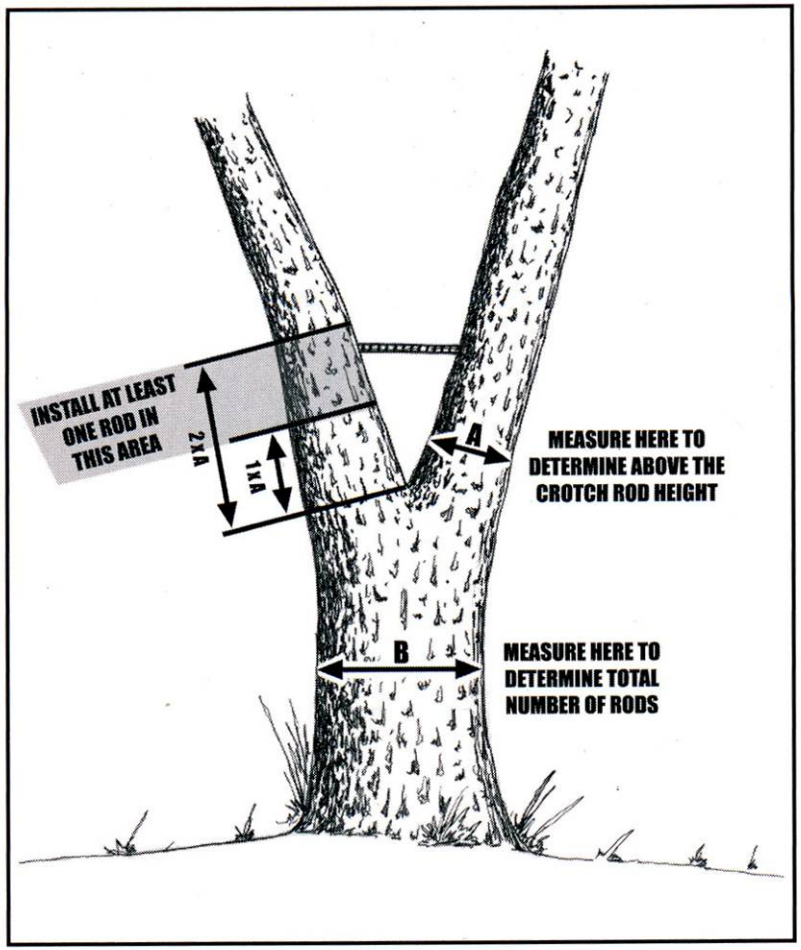

Figure 19. Determine the number of rods by measuring the diameter below the junction. Install at least one rod above the junction.

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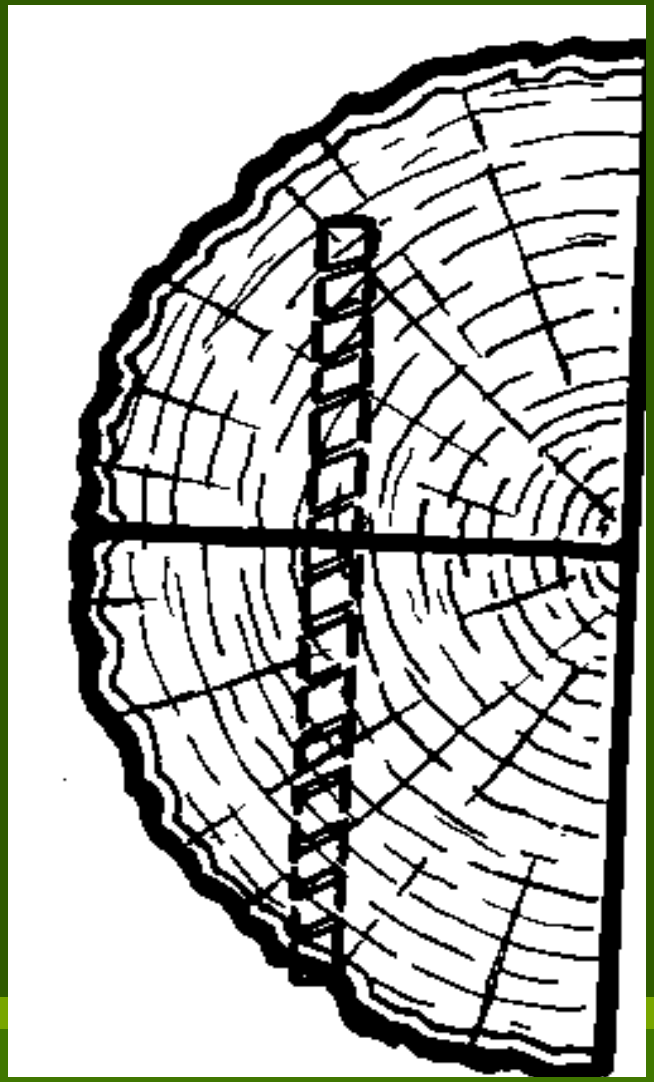
Bracing



Lag-threaded rods

- Strength comes from threads like J-lags
- Drill all the way through the small side and at least half way through the smaller stem

Bracing

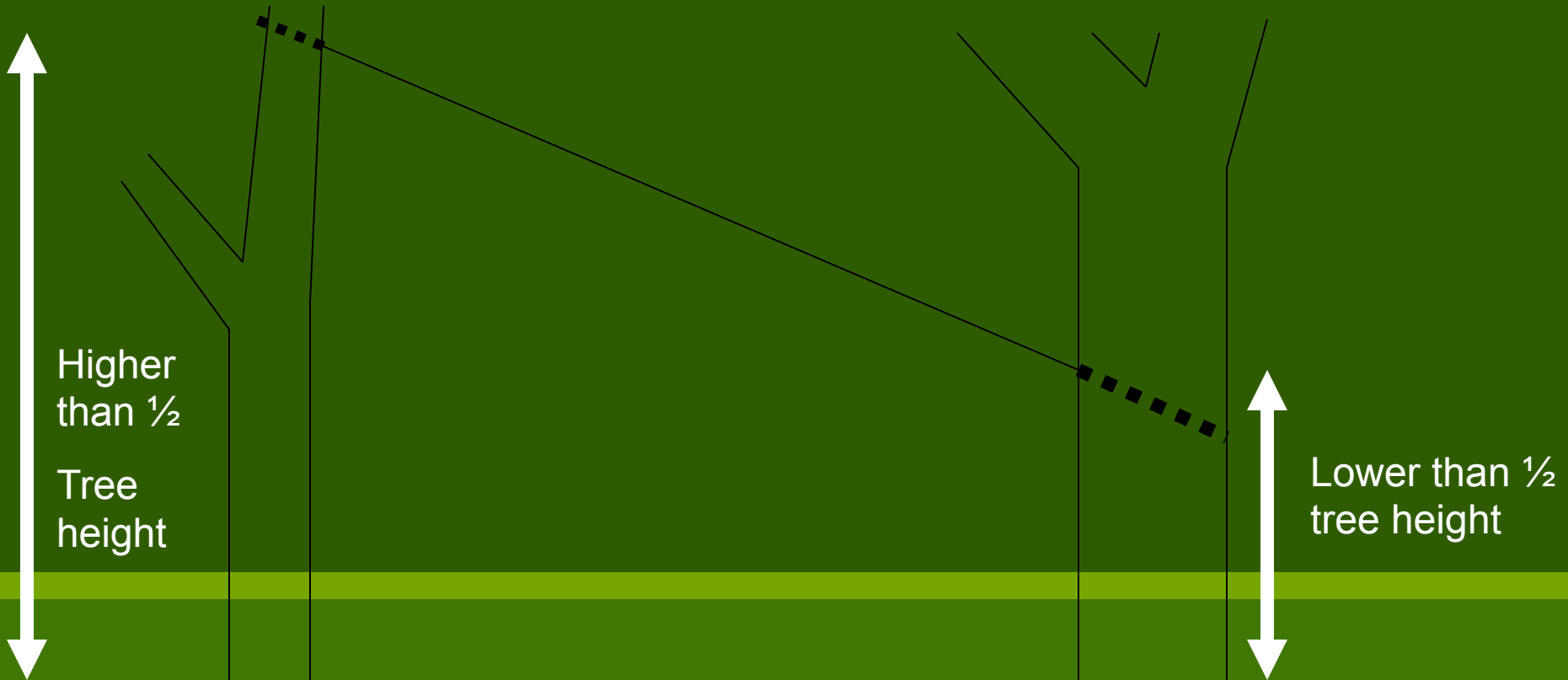
- Machine threaded rods
  - Strength comes from the tension on the outside of the wood against the washer and nut like through bolts.

Determining size and number of rods for bracing
From ANSI A300 (Part 3)-2006

Diameter at Brace (in inches)	Brace Rod Diameter (in inches)	Minimum Number of rods with Split or Included Bark	Minimum Number of Rods with No Apparent Split or Included Bark
<5	1/4	1	1
5 – 8	3/8	1	1
8 – 14	1/2	2	1
14 – 20	5/8	2	1
20 – 40	3/4	3 minimum with one additional for each 8” in excess of 30”	2 minimum with one additional for each 8” in excess of 30”
>40	7/8	4 minimum with one additional for each 8” in excess of 40”	3 minimum with one additional for each 12” in excess of 40”

Guying

- Supporting of one tree with another tree or ground anchor by use of a cable
  - The cable should be installed in the bottom half of the anchor tree and above the mid point preferably 2/3 of the way to the top of the tree in the tree being supported.



Guying

Images by Ed Hayes

Cabling / Bracing / Guying Conclusions

- Cabling bracing and guying systems provide additional support
  - They do not make a tree safe
- ANSI A300 (Part 3)-2006 is the industry standard that dictates how these systems must be installed
  - ISA Best Management Practices –the “how to guide” for the ANSI A 300(Part 3) -2006
  - Limbs over 10” diameter need through hardware
  - Anchors need to be in alignment with cable (no side loading
  - Lag hardware needs to have ALL threads fully seated in wood

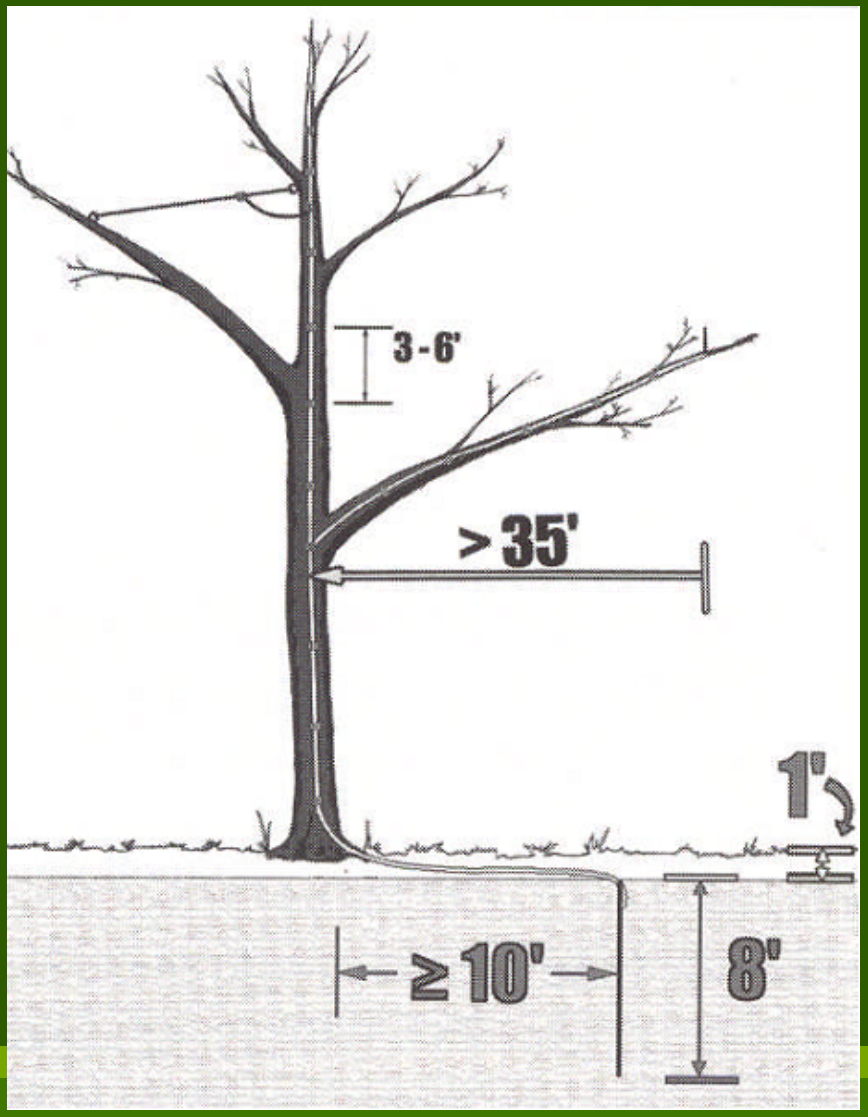
Lightning Protection

- Used to:
  - Protect important trees
  - Reduce risk side flash

Side flash

- The National Fire Protection Association's Standard for the Installation of Lightning Protection Systems (780F-1)
  - Recommends lightning protection for trees within 10 feet of a structure
    - If over or above the structure

Lightning Protection Systems
ANSI A 300 (Part 4)



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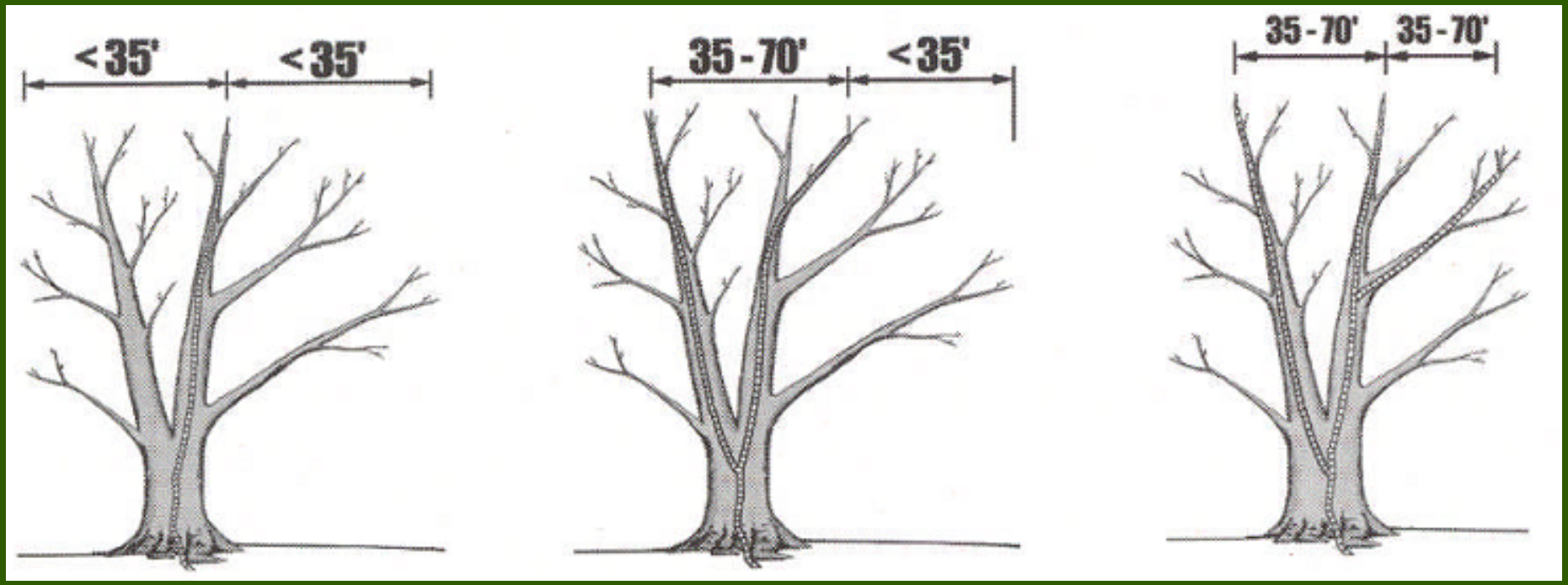

One air terminal

two air terminals

two air terminals

Lightning Protection

Air terminal – uppermost point of the system
  - Usually made of copper

Main conductor – copper conductor connected to the air terminal and runs down the trunk to the ground

Lightening Protection

- Wide spreading trees may have more than one air terminal
- Multiple leads are connected at the main trunk

Lightning Protection
Ground terminal

- **Ground rod** – a 8 foot long copper rod driven into the ground

Lightning Protection Systems Conclusions

- Lightning protection systems help to redirect electrical charges
  - They do not prevent a tree from being struck
- ANSI A300 (part 4)-2008 is the industry standard that dictates how these systems must be installed
  - ISA Best Management Practices “how to guide”