Rope Knots and Climbing

NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

TREE PRESERVATION
BULLETIN NO. 7

Rope Knots and Climbing

by A. Robert Thompson
Forester
National Park Service

TREE PRESERVATION BULLETIN NO. 7 • REVISED 1955

UNITED STATES DEPARTMENT OF THE INTERIOR

DOUGLAS McKAY, *Secretary*

NATIONAL PARK SERVICE

CONRAD L. WIRTH, *Director*

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FOREWORD

Over 20 years ago the National Park Service was confronted with the problem of improving and maintaining in good condition thousands of valuable shade, ornamental, or historically significant trees within a variety of areas. In order to guide those who were responsible for this work in park areas, a most complete and useful series of nine Tree Preservation Bulletins was prepared between 1935 and 1940 by the late A. Robert Thompson, forester in the Branch of Forestry, National Park Service. The original bulletin No. 7, *Rope, Knots, and Climbing,* was one of this series.

Although the bulletins were originally intended for park employees, they received wide use by arborists and this demand has continued. They are being reissued from time to time to meet this need.

The revised series will total seven in number. The original Bulletins 1 and 2, *Purpose and Policy,* which referred to National Park Service practices only, are being replaced by the earlier bulletin No. 9, now No. 1, *Transplanting Trees and Other Woody Plants,* and bulletin No. 8, now No. 2, *Safety for Tree Workers.* Bulletin No. 6, *General Spraying and Other Practices,* was revised and reissued in 1953 and the new bulletin No. 1 in 1954.

This bulletin, *Rope, Knots, and Climbing,* remains No. 7 in the series. Except for very minor revisions, it is essentially unchanged from the original, attesting to Bob Thompson's complete and expert knowledge of the subject.

CONRAD L. WIRTH, *Director.*

CONTENTS

INTRODUCTION

Although technicians in many varied fields must be skilled in the use of rope, knots, and methods of rigging, few have more daily need for such skills than the tree worker. He uses rope to get into a tree; as an aid in working around in a tree; as a means of lowering and raising tools, materials, and lowering tree limbs; and, most important of all, as a safety measure which prevents him from falling.

Ladders often are useful in connection with tree preservation activities, but they are awkward to transport and use and so usually are not available when needed. And, even when ladders are used, the intelligent worker always will avail himself of a rope safety sling to prevent possible accidents.

It may be truthfully said that the ability to perform efficient work in a tree is based firmly upon a thorough working knowledge of rope, knots, splices, hitches, and climbing technique. No tree worker can be considered skilled unless he possesses such basic knowledge and knows how to apply it properly.

Real skill with rope comes only with proper instruction and constant practice and cannot be obtained merely through reading. It is hoped, however, that this bulletin will serve a useful purpose in explaining some of the fundamentals of rope, knots, and climbing, and that it may be helpful up to a certain point in actual practice.

ROPE MANUFACTURE

Rope is made from several materials, among which are manila, hemp, coir, flax, cotton, and nylon. Each of these types of rope has its proper purpose, but it is with manila rope that we are immediately concerned, since this has been found to be the most efficient type and probably the most generally used for tree preservation work.

Manila rope usually is made from the fiber of the stalk of the wild banana and is obtained principally from the Philippines. In the manufacture of the raw material into rope, the fibers are twisted into yarns which, in turn, are twisted into strands. Three or four strands are laid up into a rope, and sometimes several ropes are combined into a cable.

To counteract the tendency to unlay, the successive twists are taken in opposite direction. Yarns usually are made right-handed, strands left-handed, and ropes right-handed. This twisting weakens the rope materially, at least one-third of the original strength of the fibers being lost.

The twisting adds considerably to the elasticity of the rope, however, and it is necessary for usability.

It should be clearly understood that rope does not have a permanent elastic limit, but due to the tendency of the fibers to slip upon one another, rope gradually loses its cohesion under the repetition of even moderate strains, and it may be seriously weakened by constant working. If the rope is subjected to anything approaching a breaking stress, its strength is reduced permanently, and it may be expected to break under a very moderate load.

WORKING LOADS FOR MANILA ROPE

Under average conditions the working load placed on a rope should not exceed one-sixth of the breaking stress, but under the best conditions, if the rope is new, the working load may be one-fourth of the breaking stress. Under unfavorable conditions where rope is used frequently and for an indefinite period, as in the case of a climbing rope, the working load should not exceed one-eighth of the breaking stress. The best rope for general tree work is 3-strand, long fiber, tightly twisted manila, in ½- and ¾-inch diameters which has been treated to make it resist rot and wear longer. Normally, 4-strand rope has about 95 percent of the breaking strength of 3-strand rope and hence is not so desirable.

Federal specifications for new manila rope (3-strand) include the following standards. This table should be used in estimating safe loads for manila rope used for tree work:

Approximate diameter (inches)	Approximate length of coil	Approximate gross weight of coil	Maximum weight per foot	Minimum length per pound	Minimum breaking strength	Safe load (⅛ maximum)
	Feet	*Pounds*	*Pounds*	*Feet*	*Pounds*	*Pounds*
¼	2, 750	55	0. 020	50. 00	600	75
½	1, 200	90	. 075	13. 30	2, 650	331
¾	1, 200	200	. 167	6. 00	5, 400	675
1	1, 200	324	. 270	3. 71	9, 000	1, 125

IMPORTANT KNOTS AND HITCHES

Although there are many knots and hitches which are useful in connection with tree preservation activities, those illustrated in Plate I represent the usual knots for which a tree worker will have constant need. If careful attention is paid to the illustrations it may be possible for one to learn to tie the knots shown without personal instruction. The assistance of another person who is skilled in knot tying, however, is invaluable to the beginner. Before learning to tie knots, the novice should clearly understand the names of parts of a rope. Figure 8 illustrates terms in common usage. The following comments may be of value in suggesting some of the ways in which the illustrated knots may be used:

Bowline-on-a-bight (figs. 1 and 5) is used in place of a single bowline where greater strength or increased bodily comfort is needed as in a safety sling. It may be tied in the bight of a rope without using the rope ends.

Taut-line hitch (fig. 2) is used by tree climbers as a safety knot for a body sling. It should be snugged tight before being used. (See description under Safety Sling.)

Running bowline (fig. 3) is a convenient form of running loop. It is useful for attaching rope to a high point in a tree after rope has been slung over a limb when working on the ground.

Cats-paw (fig. 4) is used for hooking a tackle to a rope. It may be tied in the bight of a rope without using the rope ends.

Safety sling (fig. 5) is a bowline-on-a-bight tied into a safety line, or a standard tree worker's safety belt or saddle in combination with a taut-line hitch. A suitable safety sling should always be used while working in a tree. (See section on Safety Sling.)

Bowline (fig. 6) is one of the most useful knots. It forms a loop which cannot slip—the harder the pull, the tighter the knot—and it does not jam easily.

Blackwall hitch (fig. 7) is used for hooking a tackle to an end of a rope.

Figure-of-eight (fig. 9) is used as a safety stop in the end of a safety rope.

Square knot (fig. 10) is the simplest and most useful of knots for tying two ropes of the same size together. It will not slip if rope is dry.

Sheet bend (fig. 11) is used for tying together two ropes of different sizes.

Two half-hitches (fig. 12) are used to tie the end of a rope around its standing part after passing around a limb or spar.

Timber hitch (fig. 13) is used for lowering limbs from trees. May be loosened easily.

Clove hitch (fig. 14) is a generally useful knot to tie a rope to a limb or spar, or to raise tools into a tree. It may be tied on the end of a rope or a bight.

PLATE I

COMMON KNOTS AND HITCHES

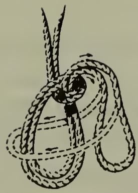

FIG. 1
BOWLINE ON A BIGHT (1)
(2)

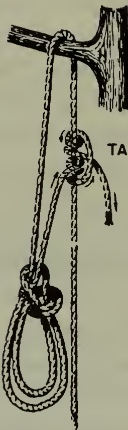

FIG. 2
TAUT-LINE HITCH

FIG. 3
RUNNING BOWLINE

FIG. 4
CATS-PAW

FIG. 5
SAFETY SLING

FIG. 6
BOWLINE

FIG. 7
BLACKWALL HITCH

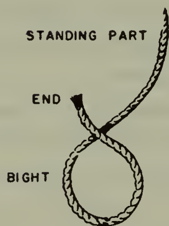

FIG. 8
PARTS OF A ROPE

FIG. 9
FIGURE-OF-EIGHT

FIG. 10
SQUARE KNOT

FIG. 11
SHEET BEND

FIG. 12
TWO HALF HITCHES

FIG. 13
TIMBER HITCH

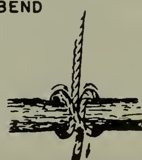

FIG. 14
CLOVE HITCH

PLATE II

COMMON ROPE SPLICES

FIG. 15
EYE SPLICE (1)

FIG. 16
EYE SPLICE (2)

FIG. 17
EYE SPLICE (3)

FIG. 23
STEEL MARLIN SPIKE

FIG. 18
SHORT SPLICE (1)

FIG. 24
HICKORY FID

FIG. 19
SHORT SPLICE (2)

FIG. 20
SHORT SPLICE (3)

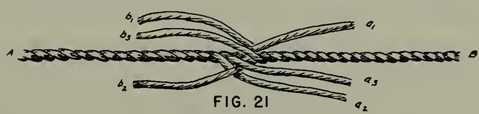

FIG. 21
LONG SPLICE (1)

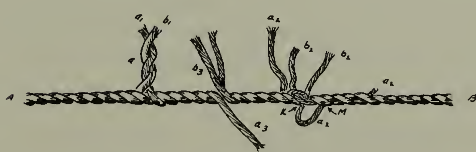

FIG. 22
LONG SPLICE (2)

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IMPORTANT SPLICES

The ability to splice two ropes together is a useful one to the tree worker. Such skill often is invaluable when no available rope is long enough to fulfill a certain purpose. When the diameter of the finished splice is of no consequence, the simplest union is the short splice, but when the diameter of the finished union cannot be greater than that of the rope itself, the long splice must be used. The latter is necessary when the splice must pass through a tackle block. The eye splice is useful when a permanent loop is needed in the end of a rope, such as in the attachment of a rope to a ring. These splices are shown on Plate I and are formed as follows:

The eye splice (see figs. 15, 16, and 17) is used for forming a permanent loop in the end of a rope. The rope strands are unwound and separated (unlaid) for a length of about 1 foot from the end. The end is then brought back against the body of the rope to form an eye of the size desired. The loop must be formed entirely of tight rope and the separated (splicing) strands should extend beyond the point of juncture. The splice is then formed by placing each splicing strand alternately over and under successive tight strands along the body of the rope away from the point of juncture and the eye itself. The splicing strands should be worked into the rope as described in the short splice.

The short splice (see figs. 18, 19, and 20) is used to join two ropes together when an increase in diameter at the splice is not important. The rope is unlaid for a short distance and the ends are brought together with the splicing strands meshed alternately (or married) as shown. Each splicing strand is worked back through the body of the adjoining rope end. This is done by placing it alternately over and under two tight strands adjacent to it in the adjoining end. When the splicing strands have been worked back past two tight strands they are trimmed to two-thirds their original diameter. The process is repeated and the strands are trimmed to one-third their original diameter. The tucking process is repeated for the third and last time, and the splice is completed.

The spike or fid (see figs. 23 and 24) are used to open tight strands thus simplifying the splicing process.

In making a long splice, the ropes are unlaid for a longer distance than in the short or eye splice before the strands are married (see fig. 21). The strand a_1 of rope A is unlaid for about a foot, and b_1 is laid into the opening, thus working a strand of B into A (see fig. 22*a*). For convenience the strands a_1 and b_1 should be twisted together as shown. Follow this same procedure by unlaying b_2 and lay a_2 into the opened lay of B and twist together as before. Then a_3 and b_3 should merely be twisted together. We now have three pairs of strands together at different points of the rope.

Then starting with b_2 and a_2 separate each strand in two parts, and, taking one-half of each strand, overhand knot these together as in Figure 22*k* and tuck them in a short splice as shown in Figure 22*m*. The other pairs of strands (a_1 and b_1) (a_3 b_3) are similarly reduced, knotted, and tucked. Then the spare half of each strand is trimmed off smooth after halves of each pair of strands have been tucked, thus completing the splice.

After any splice is made, it is a good practice to lay it on a hard surface, such as a floor or sidewalk, and roll it back and forth under the foot. This tends to make the splice smaller in diameter and also tends to equalize the tension on the various strands, thus making a stronger and firmer splice. Any loose yarns should be trimmed off so that they will not bind while the splice is passing through a block.

THROWING A ROPE

After the various knots shown in Plate I are mastered, the next important step to efficient work in a tree is a thorough knowledge of the use of a safety rope. First, the tree worker must know how it should be used to get into the tree; and second, he must be able to manipulate it so he is both efficient and safe all the time he is off the ground. A safety rope should be one-half inch in diameter.

The following descriptions apply to right-handed persons. Those who are left-handed should reverse the directions as they read and follow them.

When the rope is uncoiled, checked, and laid out on the ground, a throwing knot is formed as shown in Figures 26 and 27. This knot is for the purpose of forming a weight on the end of the rope so that the rope can be slung through a crotch and the end returned to the ground. The knot is formed by making 8 or 10 loops about 8 or 10 inches long in the hand, then wrapping the loops with about 8 turns, and pulling the bight of the rope through the upper portion of the loops. The knot should be kept tight and compact so that there will be no loose loops to catch on branches or twigs.

In throwing the rope, the bight held in the left hand is adjusted so that it just reaches the ground when the arm is straight (see fig. 27). Then 5 or 6 loops are made the same length. The knot and 1 or 2 loops are held in the right hand, and the balance of the loops are held in the left hand as shown in Figure 28.

A well-placed wide crotch free of obstructing twigs or branches is then selected. If possible, the crotch should be near the trunk and one branch above the one where the climber desires to stop. Safety ropes should never be slung over dead or badly decayed limbs.

When throwing the rope, the climber should stand facing the tree at a point which will allow a free throw of the rope through the crotch. With

Figure 25.—Inspecting rope.

Figure 26.—Throwing knot, first position.

Figure 27.—Throwing knot, second position.

Figure 28.—Ready to throw.

the right knee bent and the weight carried on the right leg, the arms should swing forward and back together to get momentum. On the last swing, the right hand should release the throwing knot, and the rope in the left hand should be released loop by loop. If the rope is aimed properly, it will go through the crotch and the throwing knot will fall on the other side. The knot should then release itself and the rope end fall toward the ground. Sometimes the end will reach the ground. If not, it will be necessary to throw running coils up the rope to whip it over the branch, or a pole pruner used to hook down the short end of the rope. Care must be exercised to prevent pulling the rope back through the crotch.

If the lowest crotch possible to reach is too high to sling a ½-inch diameter rope, a smaller rope may be thrown with a weight on the end. When the small rope is in position, the ½-inch rope may then be tied on and pulled through the crotch.

SPURS OR CLIMBING IRONS

As a general rule, climbing irons or spurs should not be used in climbing live trees. Skilled shade tree workers gave up the use of such implements years ago.

The actual mechanical injury to trees caused by spurs is probably of minor importance compared with what may be termed the secondary effect. The holes left by the sharp-pointed spurs are ideal "open doors" for fungus infection in thin-barked trees, and as harbors for injurious insects.

Climbing irons are doubtless a necessity to the utility linemen who climb bare poles, but they are definitely hazardous when used on trees, since the spurs are difficult to imbed in certain types of bark and may slip, thus causing a fall.

ROPE CLIMBING

Use of Legs Around Trunk

After the rope is properly crotched, there are several ways of using it in climbing the tree. The simplest is to use the hands and arms, hand over hand, and wrap the legs around the trunk as a fulcrum and support.

To use this method of climbing, the double rope is brought together and the climber reaches as high as possible, grasping both ropes as shown in Figure 29. Then, with the weight supported by the hands, the legs are lifted as high as possible and wrapped around the trunk as shown in Figure 30. The rope is then climbed hand over hand, still keeping the legs wrapped tightly around the trunk. When the position shown in Figure 31 is reached,

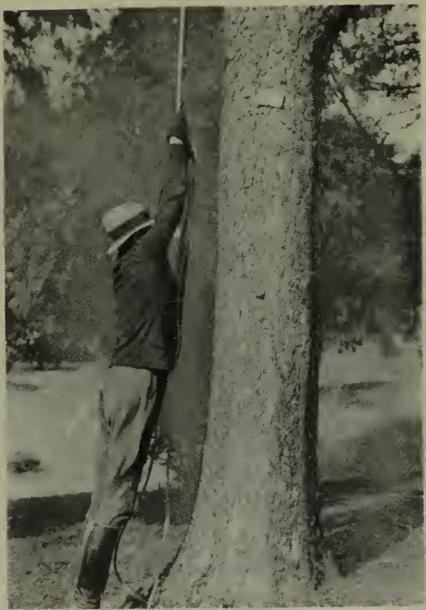

Figure 29.—Ready to climb.

Figure 30.—Legs up.

Figure 31.—Hand over hand.

Figure 32.—Up onto limb.

the legs are released and again lifted as high as possible to a new position on the trunk. This process is continued until the crotch is reached.

If a limb is encountered before the rope crotch is reached, the climber can easily transfer himself to such a limb. If it is necessary, however, to climb directly onto the limb where the rope is crotched, the limb may be approached as shown in Figure 32. In this position the right leg is swung up and hooked over the limb, which is grasped by both hands, and the left leg is used as a brace against the trunk. The body is then swung up and over the limb.

If necessary to climb higher by using the rope, one rope end is recoiled into a throwing knot and again thrown through a favorable crotch and the climbing process repeated. Usually, however, there will be sufficient limbs to serve as foot and handhold so that the tree can be climbed as a ladder. The rope end should be knotted over the shoulder or through the belt and carried up as the tree is climbed.

Use of Footlock

It is often necessary to climb a rope when the tree trunk cannot be used to assist. In this case the rope should never be climbed hand over hand without using the footlock. Experienced climbers will have their own preferred form of footlock, but for others the following footlock is suggested as an acceptable and proven standard:

With the double rope hanging free, the climber should grasp the two ropes as high as possible and raise the body with the arms. Then the right knee should be raised with the ropes passing outside the right thigh, back of the right leg, over the right instep, and over the left instep as shown in Figure 33. Then the left foot is raised and placed on the right instep, locking the rope between the left arch and the right instep as in Figure 34. In this position the entire weight of the climber should be borne by the feet. Then the arms are raised as shown in Figure 35 to a new grasp of the ropes, the footlock released, and the legs raised and locked as before. This process may be repeated as often as necessary. When the limb is reached, one leg is thrown over it and the body swung over and onto the limb. The rope is then carried higher in the tree as described previously until the final crotch for the safety sling is reached.

In order to work freely anywhere in the tree, the highest safe central crotch should be selected through which to sling the safety rope. A crotch consisting of a sound 5-inch upright branch and a 3-inch side branch is sufficient to hold the heaviest climber if the limbs are alive and undecayed. Tight crotches should be avoided as they may bind the rope and cause considerable difficulty when it is necessary to change the adjustment of the safety sling.

Figure 33.—Footlock, first position.

Figure 34.—Footlock, second position.

Figure 35.—Footlock, third position.

Figure 36.—Safety sling.

Cramps and strains should be avoided when using the footlock as well as in other types of climbing. The climber should stop and rest if he feels tired. The careful climber will not use the footlock method for a climb greater than 20 to 30 feet. For higher climbs, he may tie a bowline-on-a bight in one end of the rope and raise himself by hauling on the other end. The assistance of one or two fellow workers will be found helpful in such cases. This procedure may sound cumbersome to the trained tree worker, but it is felt to be a necessary safety precaution for high climbs, especially in the case of relatively inexperienced men.

SAFETY SLING

There are several safety belts and specially made safety slings available for use by tree workers. A bowline-on-a-bight, tied into a safety line, or a special-made safety belt, or saddle in combination with a taut-line hitch make up the safety sling.

Since this bulletin is concerned primarily with the use of rope, only the rope-type sling, the bowline-on-a-bight, is covered in detail here.

In forming this sling, one end of the rope is doubled back about 8 feet to form a bight. A bowline-on-a-bight is then tied in this loop leaving free about 2 feet of the short end. The exact size of the bowline is determined by the size of the person to use it, and it should fit snugly around the hips. After the knot is tied, the loops are placed around the body as shown in Figure 36.

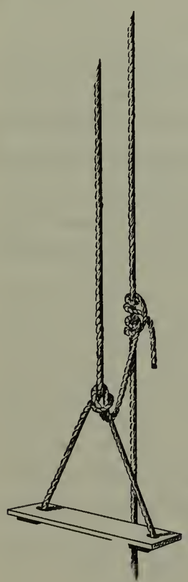

Figure 37.— Swing board.

The short end of rope protruding from the bowline-on-a-bight is then tied into a taut-line hitch around the ground rope as shown in Figure 2 and Figure 37 as follows: About 6 inches from the bowline knot, wrap the short end counterclockwise twice around the ground rope, making the secondary wrap below the first. Then, continuing in the same direction around the rope, make 2 turns above the first 2, feeding the end under the short cross rope. When completed, the wraps should be with reference to the time of wrapping—No. 3 on top, No. 4 next, No. 1 next, and No. 2 at the bottom. With the knot tied and tightened, the sling should be tested before swinging free. Always tie a figure-of-eight knot in the ground end of the safety rope to prevent the end from being pulled accidentally through the taut-line hitch.

Some climbers, when pruning, use the rope end which protrudes from the taut-line hitch for holding a can of wound dressing. In this case, the rope should be doubled back for about 15 feet before tying the bowline-on-a-bight. This will allow 4 to 6 feet of the rope to hang below the knot on which the paint can may be hooked.

If the climber expects to spend a long time in one position in the tree, the substitution of a swing board (see fig. 37) for the bowline-on-a-bight will be found more comfortable. When a swing board is used, it is held in place by a single bowline strung through the holes at the ends of the board and the bowline knot should be as close to the body as practical. The bowline and swing board are, of course, supported by the taut-line hitch as in a standard safety sling. In order to prevent splitting of the swing board, it should be made with two cross cleats underneath.

USE OF SAFETY ROPE IN A TREE

A safety rope has three major uses to the climber. It is the most convenient way to get around in a tree; it is a vital safety device; and the ground end of the rope may be used to haul up light tools and equipment.

In getting around in the tree, an efficient climber will allow his weight to be supported by the rope most of the time and use the limbs of the tree merely as guides. In this manner he can go out to the very ends of lateral branches, since his weight is carried by his rope, and the stress on the branch is endwise and not downward.

As the climber moves about in the tree, it will be necessary to readjust the taut-line hitch in order to reach the desired points. To lower the body, the knot should be jerked downward and released when you want to stop. When it is desired to shorten the safety rope or to take up slack, the taut-line hitch can be worked upward by transferring the weight of the body from the hitch to a point above it. By holding the weight by a hand above the hitch and by the feet below the hitch, using a footlock, the hitch can be slipped upward.

The safety rope is the climber's guarantee against falling from the tree. The safety sling must be kept tied and in use until the climber is again on the ground. To release the taut-line hitch before coming out of a tree is an unsafe and ill-advised practice.

In pulling tools up into the tree or in lowering them, extreme care must be used with sharp-edged tools so that they will not cut the rope or injure the climber. The best knot with which to attach a pole pruner, pole saw, or other handled tool is the clove hitch. This knot is easily tied, is safe, and is readily untied. A common cause of injury to safety ropes is the raising of pole pruners by inserting a hook in a loop in the rope. The handle often catches on a limb, thus closing the cutter on the rope with consequent damage. Care should be exercised constantly against persons standing under the tree when tools are being raised or lowered.

INSPECTION OF ROPE

Rope should be kept coiled when not in use and should be thoroughly inspected for wear, cuts, and abrasions before being used again. If one strand or more is cut or badly worn, the rope should be discarded or the abrased portion cut off.

Since the exterior appearance of a rope does not always reveal its true condition, it is well to open the strands of the rope at intervals to observe the condition of the inside fibers. If these are broken appreciably or if dust is found in quantity, the rope is probably materially weakened and should be discarded.

COILING THE ROPE

A rope must always be kept coiled when not in use. It is a sign of ignorance and carelessness to allow a rope to be put away without coiling it properly.

An efficient method of coiling a rope is illustrated in Figures 38 to 40. The rope may be looped over the left arm, as shown in Figure 38, until about 15 feet are left. Careful watch should be kept for kinks which should be straightened. Then, starting about a foot from the top of the coil, the end should be wrapped about 6 times around the loops by rolling them in the left hand as shown in Figure 39. Then the left hand is extended through as shown in Figure 40, and the bight is pulled back through the loops. Two half-hitches are then tied around the bight, leaving a short end for carrying or tying to a peg or support bar (see fig. 41).

ROPING AND CLIMBING STANDARDS

The following standards and restrictions are created solely as a means of protecting tree workers from injury. Each one is important and must be thoroughly understood and followed.

1. The standard safety rope is a first-grade, 3-strand, rot-treated, ½-inch diameter, manila rope not less than 120 feet and preferably 150 feet in length. The ½-inch nylon rope is coming into wider use and is acceptable

Figure 38.—Coiling rope—first position.

Figure 39.—Coiling rope—second position.

Figure 40.—Coiling rope—third position.

Figure 41.—Coiling rope—fourth position.

as a standard rope if preferred. Inexpensive substandard rope should be avoided.

2. The safety sling should always be used while working in a tree even if a ladder is also used. Many men have been badly injured or killed by not observing this cardinal rule.

3. Every rope must be thoroughly inspected for cuts or abrasions before use. Don't hesitate to cut off a weak end or to discard questionable rope. Don't "burn" a rope by lowering it too rapidly, and use care against dropping cigarettes on ropes.

4. The ground end of a safety rope should not be left dangling over roadways, and it must be kept free from obstructions.

5. A rope must not be climbed hand over hand without using a footlock or using the legs around the tree. "Shinning" more than 15 feet up a tree is an unsafe practice. Climbs over 30 feet should be made by using a safety sling. Avoid fatigue or cramps.

6. All slack must be kept out of the safety rope. If it becomes necessary to change the supporting crotch of a safety sling, the climber should use great care while changing crotches. To be absolutely safe, the climber should tie himself to a convenient limb while making the change.

7. All rope must be kept coiled when not in use. Rope deteriorates rapidly when it is saturated with water and improperly dried, so unnecessary wetting should be avoided. Rope should not be allowed to freeze after wetting, as frozen rope breaks easily. Rope should not be left in a tree overnight when there is reason to expect rain, or where it might be damaged or stolen.

8. Rope should not be dragged along the ground, over rough surfaces, or across itself, and sharp bends over unyielding surfaces should be avoided. Rope should never be stored or transported where sharp tools may cut it.

9. Kinking is one of the main causes of injury to manila rope and should be avoided, especially when the rope is wet. To avoid kinks in new rope when uncoiling, uncoil from the inside of the coil—never from the outside.

10. All knots should be removed from a rope at the end of a working day. To leave knots tied for a prolonged period will cause kinking and undue wear.

11. Except under exceptional circumstances, trees should not be climbed or worked in when wet. It is impossible to get a good foothold or hand-hold on slippery bark, and knots are apt to slip if the rope is wet.

12. Remember: A good safety rope is the tree worker's most important accident insurance policy—use it.

Weight of green logs

To use: Multiply length of log in feet by the weight of a 1-foot section, using the mean diameter of the log.

Species	Weight per cubic foot[1]	Weight of 1-foot sections based on mean diameters													
		10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch	36-inch
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Apple	55	30	43	59	77	97	120	145	173	203	235	270	307	347	388
Ash, white	48	26	38	51	67	85	104	126	150	177	205	235	267	302	338
Basswood	42	23	33	45	59	74	92	111	132	155	180	206	235	265	297
Beech	54	29	42	58	75	95	118	142	169	199	231	265	301	340	381
Birch, paper	50	27	39	53	70	88	109	132	157	184	214	245	279	317	353
Birch, yellow	57	31	45	61	80	101	124	151	179	210	244	280	319	360	403
Butternut	46	25	36	49	64	81	100	121	144	170	197	226	257	290	325
Cherry, black	45	25	35	48	63	79	98	119	141	166	192	221	251	283	318
Chestnut	55	30	43	59	77	97	120	145	173	203	235	270	307	347	388
Cottonwood	49	27	38	52	68	86	107	129	154	180	209	240	273	310	346
Elm, American	54	29	42	58	75	95	118	142	169	199	231	265	301	340	381
Gum, black	45	25	35	48	63	79	98	119	141	166	192	221	251	283	318
Gum, red	50	27	39	53	70	88	109	132	157	184	214	245	279	317	353
Hackberry	50	27	39	53	70	88	109	132	157	184	214	245	279	317	353
Hickory, shagbark	64	35	50	68	89	113	140	169	201	236	273	314	357	403	452
Honeylocust	61	33	48	65	85	108	133	161	192	225	261	299	341	385	431
Magnolia, evergreen	59	32	46	63	82	104	129	156	185	217	252	289	329	372	417
Maple, red	50	27	39	53	70	88	109	132	157	184	214	245	279	317	353
Maple, silver	45	24	35	48	63	79	98	119	141	166	192	221	251	283	318
Maple, sugar	56	31	44	60	78	99	122	148	176	206	239	275	313	353	396

Oak, black	62	34	48	66	86	109	135	163	194	228	265	304	346	390	437
Oak, live	76	41	60	81	106	134	166	200	238	280	324	372	424	478	536
Oak, red	63	34	49	67	88	111	137	166	198	232	269	309	251	397	445
Oak, white	62	34	48	66	86	109	135	163	194	228	265	304	346	390	437
Osage-orange	62	34	48	66	86	109	135	163	194	228	265	304	346	390	437
Pecan	61	33	47	65	85	108	133	161	192	225	261	299	341	385	431
Persimmon	63	34	49	67	88	111	137	166	198	232	269	309	250	397	445
Poplar, yellow	38	21	30	40	53	67	83	99	119	140	162	186	211	239	268
Sassafras	44	24	34	47	61	78	96	116	138	162	188	215	245	277	310
Sycamore	52	28	41	55	72	92	113	137	163	191	222	254	290	327	366
Walnut, black	58	32	45	62	81	102	126	153	182	213	248	284	323	364	409
Hemlock, eastern	50	27	39	53	70	88	109	132	157	184	214	245	279	317	353
Pine, northern white	36	20	28	38	50	64	78	95	113	133	154	176	201	227	254
Spruce, red	34	19	27	36	47	60	74	90	106	125	145	166	189	214	239
Tamarack	47	26	37	50	65	83	102	124	147	173	200	230	262	295	331

1 From *Strength and Related Properties of Woods Grown in the United States.*

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BIBLIOGRAPHY

Austin, W. F. (Chm. Acc. Prevention Com.) *Manual of Accident Prevention in Construction.* Associated General Contractors of America, 1930. pp. 125–26.

Corps of Engineers, U. S. Army. *Engineer Field Manual.* Washington, Government Printing Office, 1917. pp. 165, 166, and 174–85.

Dana, R. T. *Handbook of Construction Plant.* McGraw-Hill Book Company, 1918. pp. 565–69.

Dutch Elm Disease Organization. *The Climbing Rope and Its Uses.* New York, 1934. (Mimeographed instructions.)

Knight, A. M. *Modern Seamanship.* D. Van Nostrand Company, 1918. pp. 24–44.

Markwardt, L. J., and Wilson, T. R. C. *Strength and Related Properties of Woods Grown in the United States.* U. S. Department of Agriculture, 1935. (Technical Bulletin No. 479).

Overholt, Virgil. *The Use of Rope on a Farm.* Ohio State Agricultural College, 1936. 48 pp. (Bulletin No. 82).

Riley, H. W., Robb, B. B., Behrands, F. G. *Hitches, Knots, and Splices.* New York State College of Agriculture, 1923. 76 pp. (Extension Bulletin No. 62).

Thompson, A. Robert. *Shade Tree Pruning,* Washington, National Park Service, Revised 1955, 25 pp. (Tree Preservation Bulletin No. 4).

——— ——— *Safety for Tree Workers,* Washington, National Park Service, 1937, 29 pp. (Tree Preservation Bulletin No. 8).

Van Der Veer, N. R. *The Bluejackets Manual.* Military Publishing Company, 1918, pp. 259–69.

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