By Order of the Secretary of the Army:

CREIGHTON W. ABRAMS,
General, United States Army,
Chief of Staff.

Official:

VERNE L. BOWERS
Major General, United States Army,
The Adjutant General.

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TACTICAL LAND CLEARING

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*This manual supersedes DA Pamphlet 525-6, 16 June 1970.

CHAPTER 1

INTRODUCTION

1-1. Purpose

The purpose of this manual is to provide commanders and their staffs with information and data which can guide them in their conduct of tactical clearing operations. It provides a consolidation of the latest information and guidance to personnel responsible for planning land clearing operations and for utilizing and supervising engineer units engaged in such operations. Additionally, the manual provides information about equipment and methods used by civilian land clearing agencies that are also applicable to military clearing operations.

1-2. Scope

This manual contains information on how to evaluate clearing requirements, determine the amount of effort required, select the most efficient means to clear the vegetation, and support and secure land clearing units. The necessity for sound prior planning is emphasized throughout this manual because it is a major lesson to be learned from the clearing operations conducted up to now. Good planning will insure that the specifications are consistent with the purpose for clearing, which is essential to avoid wasted effort resulting from clearing too thoroughly in one area and not thoroughly enough in another. Clearing for agricultural or forestry purposes specifically is not included. However, the potential civic action benefits to be derived from a clearing project, such as making more agricultural areas available and providing felled vegetation for lumber, should always be considered, due to the favorite social and economic impact on the local populace.

1-3. Application

In addition to information specifically pertinent to tactical land clearing, this manual contains a variety of data and information having application to land clearing in general. These are included because tactical land clearing operations can utilize most of the engineering considerations and techniques discussed therein. At the same time, it should be kept in mind that tactical land clearing operations are a distinctive, separate, and highly specialized type of combat operation normally conducted by combined arms groupings supported by TOE engineer land clearing companies (or composite or provisional engineer land clearing battalions) and other engineer units as may be appropriate. Land clearing on a relatively small scale may be conducted in mid-intensity or higher level warfare by any engineer unit equipped with land clearing plows and related equipment. However, large-scale land clearing operations in a counterinsurgency environment or in low-intensity warfare where enemy forces make extensive use of heavily forested areas for their bases and operations will normally be accomplished with the support of specialized engineer land clearing units as indicated above.

1-4. Changes

Users of this publication are encouraged to submit recommended changes and comments to improve the publication. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forwarded direct to the Commandant, US Army Engineer School, Fort Belvoir, Virginia 22060.

CHAPTER 2

TACTICAL LAND CLEARING OPERATIONS

Section I. CONCEPT AND PLANNING

2-1. Purpose of Tactical Land Clearing Operations

a. A tactical land clearing operation is a combined arms operation having the objective of destroying, disrupting, or neutralizing enemy forces and facilities in a counterinsurgency environment in which enemy activities and unite are using heavily forested areas for cover and concealment. Land clearing and other related combat support functions performed by engineers are primarily intended to enhance and complement the mobility, firepower, surveillance, and target acquisition capabilities of all elements in the combined arms grouping. A tactical clearing operation usually includes some or all of the following subsidiary objectives:

(1) Deny the enemy cover and concealment.

(2) Channelize the enemy's infiltration and movement.

(3) Deny the enemy concealed base areas.

(4) Deny the enemy ambush sites adjacent to land lines of communication.

(5) Provide aerial and antipersonnel radar observation lanes.

(6) Provide observation and fields of fire for perimeter defense of friendly installations.

(7) Enable friendly forces access to and control of key terrain features. Provide off-road cross-country tactical vehicle mobility to friendly units. One land clearing operation can be planned to accomplish several of the objectives listed above. Tactical counterguerrilla operations in heavily forested areas sometimes succeed in driving the enemy from jungle areas, but have not been successful in keeping him out. Land clearing, by felling and disposing of the vegetation in these critical areas, can effectively deny the enemy their use.

b. A secondary benefit from a tactical land clearing operation is that it often enhances the economic status of the area. Consistent with the tactical situation, marketable timber felled during clearing can be left for the local lumbering industry. Clearing also converts dense jungle areas into potentially useful agricultural areas. If food production or lumber is critical to the economic development and stabilization of an area, land clearing can be accomplished primarily for these civic action benefits.

2-2. Responsibilities

a. Tactical land clearing missions should be conducted by combat units and/or combined arms groupings of battalion-size or larger. Engineer land clearing units and other engineer units, as may be appropriate, are attached or placed in support of the combat unit commander. The commander of the combat unit or combined arms group is responsible for the conduct of the land clearing operation. The land clearing requirements, in support of the tactical objectives, are identified, developed, end established by each tactical commander for his area of responsibility. Due to the highly specialized nature of tactical land clearing operations and the extensive commitment of engineer resources usually involved, the advice and assistance of the staff engineer of the tactical commander concerned is of particular importance in formulating the tactical land clearing plan. In order to make a sound land clearing estimate and plan, specific quantitative descriptions of the vegetation on the site to be cleared are required. Timely arrangements are made to integrate and coordinate the application of land clearing resources available from or being employed by higher and collateral commends. Coordinative details and supporting arrangements are included in the tactical land clearing plan. Factors such as tree count, tree size, wood density, root system, vines, and undergrowth significantly affect production in land clearing operations. Allocation of land clearing resources, and details of timing and phasing for execution of the operation, should be clearly defined with due consideration to the effect of terrain, weather, and enemy activity on the capabilities and limitations of land clearing resources. Terrain and weather conditions, such as large swampy areas and monsoons, must be considered when allocating land clearing resources. Because tactical lend clearing is often conducted in strongly held enemy territory, the land clearing force must contain sufficient tactical troops to provide protection for the land clearing unit. The enemy recognizes the effect of land clearing upon his operations and may be willing to sacrifice his own resources in attempts to disable or destroy land clearing equipment.

b. The tactical land clearing plan must also

consider the long range requirements for continued denial of the area through a program of regrowth control and secondary clearing. Tactical clearing should be coordinated closely with the civil affairs staff to maximize its benefit in the stabilization of the area and minimize the adverse effects of land clearing operations on the local populace.

2-3. Unit Capabilities

a. Troop units participating in tactical land clearing operations must be mounted in tracked vehicles to facilitate movement and observation, and to enable delivery of large volumes of firepower on the enemy. TOE or provisionally organized engineer land clearing companies and battalions should be employed as primary land clearing elements. The TOE engineer land clearing company is discussed more fully in the next subparagraph. Other engineer units, which may also be equipped with land clearing plows and related equipment, can be used to accomplish supporting and complementary clearing tasks as well as to provide other forms of engineer support for the tactical clearing force.

b. Due to the requirement for the clearing of vast areas to deny the enemy sanctuaries in counter-guerrilla operations in a heavily forested or jungle environment, a highly specialized land clearing company has been organized. The missions of this company, now organized under TOE 5-87, are to—

(1) Destroy or clear extensive dense vegetation in critical areas for the purpose of denying their use by the enemy as bases of operation, supply bases, marshaling areas, ambush sites, and cover and concealment.

(2) Clear dense vegetation from areas adjacent to friendly installations for the purpose of improving installations security by providing observation and fields of fire, and reducing ambush probability along land lines of communications.

c. This engineer land clearing company normally is assigned to a corps with reassignment or attachment to an engineer combat brigade or engineer combat group. The major items of equipment of the engineer kind clearing company include 30 medium (180 hp) tracked tractors equipped with angled shearblades, 12 full-tracked 6-ton carriers, disk harrows, chain saws, air compressors, welding shop, generators, and various cargo and utility trucks. In addition, this unit can provide its own direct support (DS) maintenance and maintain a mission load of repair parts for the following mission essential items organic to the company:

(1) Chain saws.
(2) Air compressors.
(3) Grinding machines.
(4) Disk harrows.
(5) Tracked tractors and attachments.

d. Additional capabilities of this company are shown in TM 5-142 and in TOE 5-87. The engineer land clearing company is internally self-supporting, but is designed to operate as part of a larger force or task grouping which provides for external support. It consists of a company headquarters, transportation and maintenance platoon, and three identical land clearing platoons (fig 2-1). This company may be employed to accomplish a variety of land clearing operations to include large area clearing missions requiring the total company effort (30 tractors), missions requiring a platoon size effort (10 tractors), and missions requiring effort of a single section (5 tractors). The company may be attached to or placed in support of engineer battalions engaged in land clearing or other engineer operations. The company may also be employed independent of other engineer units as an attached-or supporting component of the tactical force involved. Additionally, two or more companies may be provisionally organized into a land clearing battalion and employed as outlined above or independently. Preservation of land clearing unit integrity is of particular importance to facilitate control and support of land clearing plows as well as to derive increased efficiency and production inherent in en masse employment of the unit. If the company is fragmented into smaller organizational elements, it should only be for short periods of time and under exceptional conditions because the maintenance platoon operates most efficiently as a single element and prolonged fragmentation will result in loss of a desirable maintenance posture.

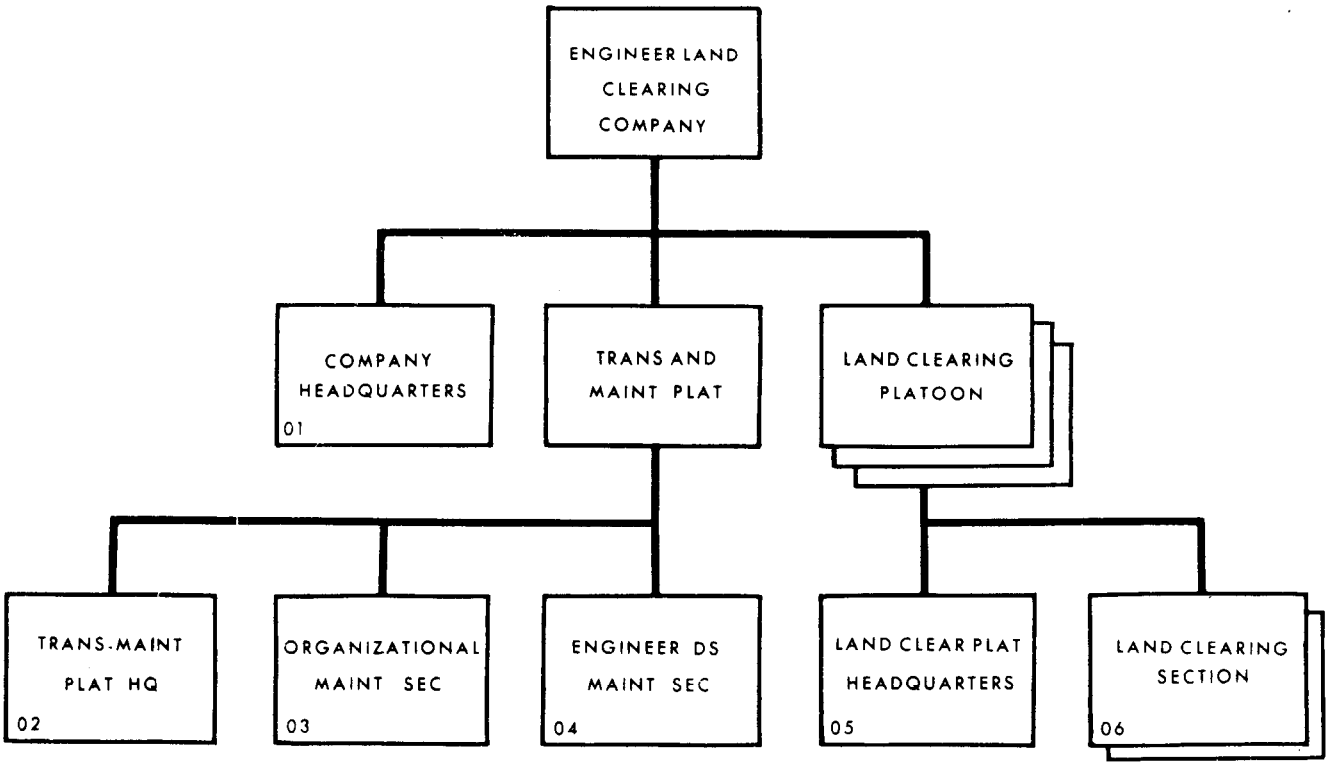


Figure 2-1. Engineer land clearing company.

2-4. Planning an Operation

The major steps in planning a land clearing operation are as follows:

a. Establish clearing specifications, priorities, timing, and phasing as may be appropriate for subordinate tasks and units.

b. Provide for security of the land clearing unit.

c. Provide for support requirements.

2-5. Clearing Specifications

a. After the reason for clearing a particular area has been determined, the specifications defining the required results must be established. Clearing involves the expenditure of a considerable amount of effort. Care should be exercised so that the specifications require only the amount of clearing necessary to accomplish the objective.

b. One of the first considerations is the length of time that the area must remain clear of vegetation. If the future use of the area indicates that long term clearing is required and regrowth is to be controlled using either herbicides or mechanical means, the area must be cleared more thoroughly than if it is not be re-entered. If regrowth is to be mechanically controlled, all stumps must be cut to no more than 12 inches above the ground. Higher stumps will interfere with tractors returning to the area for regrowth control and if they inadvertently straddle a high stump, the belly pan and undercarriage of the tractor can easily become damaged. If the vegetation is in excess of 12 inches in diameter, it should be winrowed and burned after the initial clearing, if regrowth is to be controlled mechanically. Windowing patterns and techniques are discussed in paragraph 2-9 *e.* Isolated large trees, 3 feet or more in diameter, can be left standing because they provide less cover to the enemy in a vertical position. Cutting these large trees even with a shearing blade is a time-consuming process because of the extra splitting effort required.

c. An approved overlay defining the specific area to be cleared must be provided to the land clearing unit commander and all interested parties prior to the start of the operation. This is necessary to preclude confusion in reporting progress or when referring to cut areas. Any changes or deviations should be made only after careful analysis, and approval by proper authority.

2-6. Security of the Land Clearing Unit

Security of land clearing personnel and equipment is extremely critical to the success of a land clearing operation. The land clearing unit has too little organic capability to furnish its own security either in the cut area or in the night defensive positions. Provision of adequate security is the responsibility of the tactical commander responsible for the conduct of the land clearing operation.

a. The enemy recognizes the effect of land clearing on his operations and is willing to assume great risks to harass or prevent the operation. The security force must be aggressive, alert, and responsive at all times. The amount of security forces necsssary will vary according to the enemy situation. The tactical or security element commander and the land clearing unit commander must coordinate their activities very closely in the cut area. The land clearing unit commander must advise the tactical unit on the deployment of his troops to obtain maximum security with minimum interference with the clearing operation. Special consideration should be given to the enemy's capability to place mines and booby traps in the cut area. All clearing tractors are extremely vulnerable to mining activity. The enemy may also attempt to ambush or attack the clearing unit in the cut or on the march between the cut and the night defensive position (NDP).

b. The night defensive position for a land clearing company serves as both a secure night bivouac position and a maintenance base during both night and day. An example of a typical NDP is shown in figure 2-2.

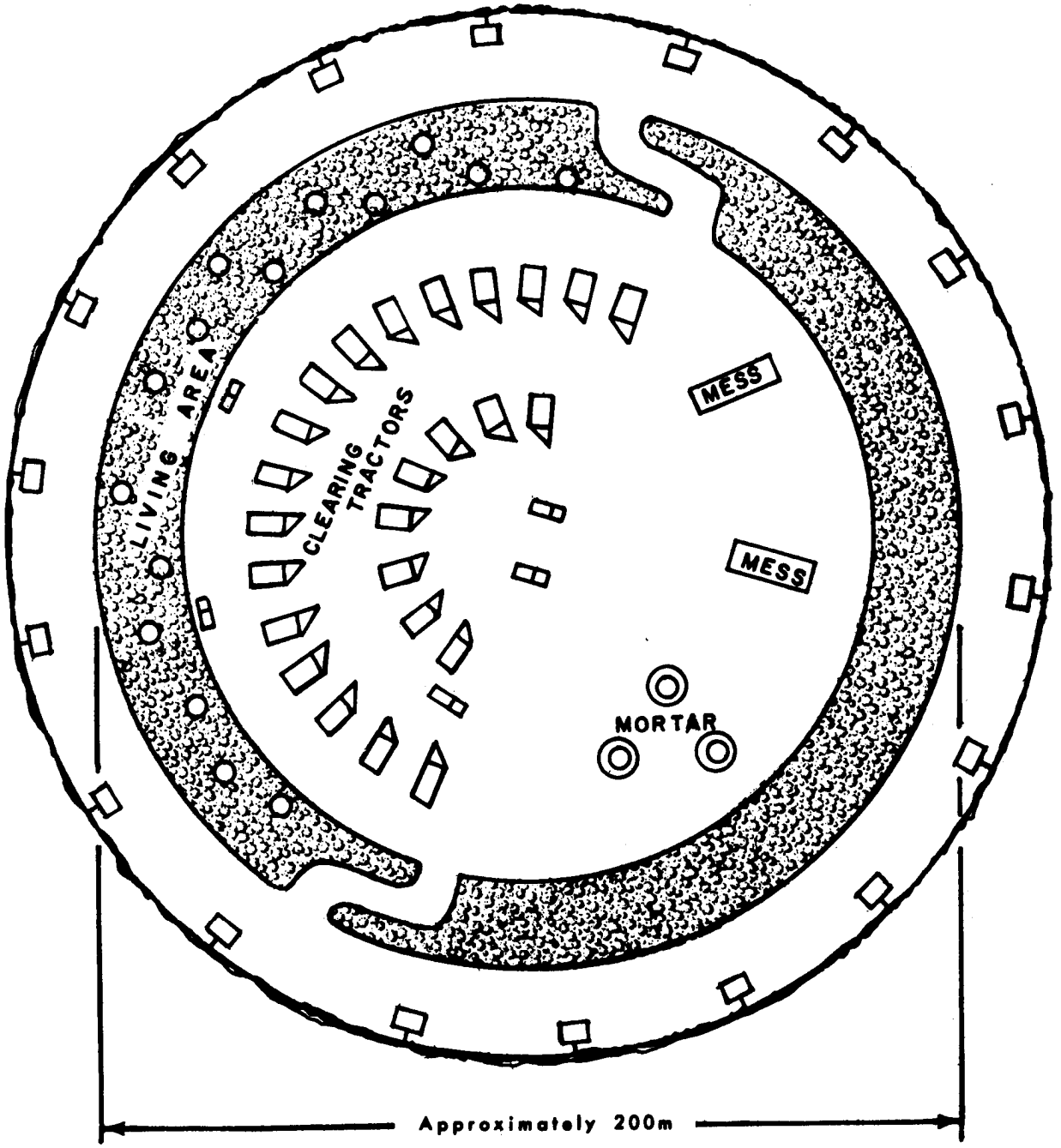


Figure 2-2 Night defensive position.

(1) This circular area of 200 meters minimum diameter is constructed in a doughnut configuration, leaving a ring of jungle between the outer defensive berm and the center area. Mines and boobytraps may dictate complete clearing; if not, the ring of jungle provides concealment for maintenance and mess areas, and for mortar positions. The entrances to the center are constructed to preclude direct observation from the out side. Maintenance and other activities can be conducted using lights during the hours of darkness, with the concealment provided by the opaque ring of jungle. The maintenance activities of a land clearing unit in the field will often require night work, so an NDP similar to this is absolutely essential if the maximum number of operational tractors are to be kept in the cut on the following day.

(2) The NDP should be located on well drained terrain near the road net if land resupply is anticipated. Its location on well drained terrain is especially essential during the monsoon or rainy season. If drainage is not adequate during the rainy season the NDP can become a quagmire as the tractors disturb the soil in the center and make it untrafficable. When this occurs maintenance activities are severly hampered.

(3) The NDP should be located not more than 4 km from the cut area. Four km is normally the maximum distance the tractors should "walk" to the cut area.

c. When the NDP is to be moved as the clearing progresses, adequate time must be allowed to insure that a new NDP can be completed prior to nightfall. New NDP's should be occupied or secured immediately in order to prevent covert mining by enemy elements. To the maximum extent possible, security forces must relieve the land clearing unit of the burden of perimeter security in the NDP. Conversely, fields of fire, access routes, weapon and STANO sites for the security element will be cleared by the land clearing unit under the direction of the tactical commander during the initial construction of the NDP.

d. During operations in the cut area the land clearing company is spread over a wide area and continually on the move. It is important that the security elements be mobile and responsive to keep up with the continually shifting operations and to move rapidly in response to an ambush or attack. The composition and strength of security elements is established by the tactical commander conducting the clearing operation. The mobile form of security and firepower required in tactical land clearing can beet be provided only by mechanized infantry, armored cavalry, and armored units. The size of the force required will be governed by the tactical situation. An armored cavalry troop reinforced by a tank platoon has effectively secured one land clearing platoon. Infantry foot troops can be used as security when the land clearing element is engaged in a long strip clearing operation and there are sufficient troops to outpost and secure the perimeter of the area being cleared.

e. Security vehicles and personnel should not approach land clearing tractors closer than 30 meters while they are moving. This will preclude accidental injury to personnel and damage to vehicles in the event a tractor detonates a mine or booby trap. Falling trees can also severely damage unprotected equipment and injure careless personnel. The clearing tractor operator's visibility is severely restricted by the protective cab so personnel must use extreme caution when approaching moving tractors under any circumstance. When moving between the cut and the NDP a good tactic is to have the column led by a radio equipped tractor with a bulldozer blade, followed by a tank. The bulldozer blade can clear a path for the clearing tractors and APC's and will also detonate any mines encountered. The convoy should not use the same route to and from the cut, in order to minimize enemy mine effectiveness. No equipment should move between the cut and NDP at night or without proper security escort. It may be necessary to set up a convoy from the cut to the NDP at midday in addition to the morning and afternoon convoys to evacuate inoperative tractors for maintenance and repair.

f. In order to discourage ambushes, minelaying parties, and other enemy activity in the cut area, harassing and interdictory fires should be directed at avenues of approach and into the area to be cleared the following day. Artillery preparation of the cutting area prior to the start of work is advisable. These fires should be scheduled early enough to be completed prior to the arrival of the clearing unit in the morning so the start of work is not delayed. Ambush patrols and reconnaissance by fire can also assist in locating enemy elements and discourage snipers and rocket propelled grenade attacks. The most likely avenues of approach, streams, trails, etc., to the cut area should be cleared first to improve friendly surveillance capabilities and deny covert enemy access to the cut area.

g. When required by tactical circumstances, enemy activity, or the land clearing plan, teams of land clearing and security force elements may be diverted from general clearing operations to penetrate into or isolate a known or suspected enemy position. The tractors lead by clearing only the undergrowth and small trees and avoiding large trees or impediments that would delay progress. Speed is the key to such operations and knocking

down large trees not only takes time, but also impedes the progress of tactical vehicles through the cut area. By moving through the undergrowth only, a task force can proceed far faster than enemy foot soldiers can possibly move. The success of such operations depends heavily on the availability of a command and control helicopter, communicantions with all tractor operators as well as the combat force, and immediate fire support, either from air or atrillery. Since there may be little or no time for prior planning in such operations, land clearing units should be trained in rapid response missions and, whenever possible, the combined arms forces conducting land clearing operations should rehearse.

h. Security forces must be informed that immobilized equipment means trouble and that they should investigate immediately. The operators will stop their tractors only if they have experienced mechanical difficulties that prevent them from moving to a secured area, if in contact with the enemy, or if they have discovered a dud round, mine, or boobytraps. The dud rounds, mines, and boobytraps should be marked immediately to prevent equipment or personnel casualties. When operations are conducted in an area of high mine and boobytrap density, engineer demolition teams and EOD personnel should be attached to the land clearing unit to dispose of them. Land clearing tractor operators are constantly exposed to sniper fire, ground attack, and mines, and are usually the first to find enemy bunkers or tunnels hidden by the heavy vegetation.

i. Voice communication between operators is impractical bacause of the noise of the tractor. To signal "danger withdraw" to other operators and alert the security forces, each operator should be given a supply of colored smoke grenades for use when danger threatens. Tractor operators can be equipped with AN/PRR-9 radio receivers and transmitters to maintain control of operations and contact between operators. Experience has shown this practice can improve morale and also reduce personnel and equipment casualties. The AN/PRC-25, with headsets, can also be used and has been found in some instances to be more efficient.

2-7. Support Requirements

a. Aviation Support. Reconnaissance is an essential factor in area clearing operations. It is extremely difficult for the clearing unit commander to control his unit, make sound plans, or make an accurate assessment of the clearing to be accomplished in a hostile area without daily aerial reconnaissance. The minimum required aviation support is two helicopter sorties daily, one for 2 hours at the start of work in the morning and one for an hour at the end of the workday. Aerial photograph flights of the cut area before, during, and after the clearing operations are beneficial in accurately determining the quantity of clearing accomplished. In remote areas where logistical trains can reach the land clearing unit only with great difficulty, aviation support is required for supply of rat ions, POL, repair parts, ammunition, and other supplies. Utility helicopter support for high priority administrative and maintenance items is also essential and should be integrated with reconnaissance missions. Time sharing of a helicopter is not normally satisfactory because the daily reconnaissance flights must be accomplished on time or the entire land clearing effort is delayed.

b. Engineer Support. The tactical commander is responsible for providing combat engineer support for the tactical clearing operation. In terrain that is interlaced with streams, canals, or steep-sided gullies it is necessary to provide bridging to cross the land clearing tractors or security force vehicles. Supporting engineer troops are necessary to install bridging across these obstacles. The armored vehicle launched bridge (AVLB) is extremely effective for this purpose. It can be used several times in a cut area with little expenditure of manpower and time. It may also be necessary to install rafts, floats, or more extensive bridging to complete the cut area. Combat engineers may also be required to conduct daily mine sweeps of the cut area and routes to and from the cut area. If the clearing plan or specifications indicate larger vegetation or that on steep slopes, vegetation is to be felled using chain saws or explosives, combat engineers and demolitions specialists would have to be used to accomplish this work. These engineers will also detonate any mines, boobytraps, or dud rounds found in the cut area. Another piece of engineer equipment that can add support to land clearing operations is the combat engineer vehicle (CEV). The versatility of the CEV makes it useful in that it has light dozing capabilities, lifting capabilities with its hydraulic boom, and can provide additional security with its armament of a 165-mm demolition cannon, M73-7.62-mm coaxial machinegun, and M85 0.50-caliber machinegun. In addition, a mine roller can be mounted on the front of the vehicle to facilitate detonation of pressure sensitive mines in its path.

C. *Logistics Requirements.* A land clearing company, even more so than other engineer units, bears a particularly heavy logistical burden. The tractors may consume up to 1800 gallons of diesel fuel daily. An average of 800 pounds of repair parts is necessary each day. This figure will vary widely when major components such as tractor engines tire transported. Over 2000 gallons of water is the normal daily consumption for equipment, mess, and

personnel. When clearing heavy vegetation utilizing explosives, 1000 pounds of C-4 may be required daily. The parent engineer organization through its support channels is normally capable of coordinating all the necessary logistical and maintenance support. However, additional transportation either by air or by ground may be required. Since land clearing tractors whould not be directed from their primary tasks for extraction of disabled vehicles, a heavy recovery vehicle should be furnished by the tactical commander for this purpose. Recovery operations are discussed in detail in appendix C. For the purpose of tactical movement a land clearing company is only 30 percent mobile in organic vehicles. In order to make a one-lift tactical movement it must be supplemented by twenty-two 10-ton tractors and 25-ton semitrailer low-beds.

Section II. CLEARING PROCEDURES

2-8. Types of Cut

Tactical land clearing is normally accomplished using one of three basic techniques depending upon the size and shape of the area and type of vegetation to be cleared.

a. Area Clearing. This technique is used when clearing large areas of heavy vegetation. Whenever possible, the land clearing company commander selects three areas, each generally 70 to 125 acres (300,000 to 500,000 square meters), one area for each platoon of 10 clearing tractors. These areas are defined by a clearing a "trace" counterclockwise around the perimeter. Each area is to be completely cleared during 1 day's operation. One, figure 2-3 illustrates a typical three-platoon area clearing layout. Often three-platoon areas are not feasible, because of a shortage of control aircraft or tractors. Also, in heavy vegetation and difficult terrain, it takes the full attention of the OIC in a helicopter to guide a single trace. Two, figure 2-3 shows the use of tractors protected by APCs (or infantry) in securing a strip clearing operation. Three, figure 2-3 shows the use of tractors and APC's to allow mobile defense during a land clearing. The security forces are fragmented between each separate cut area when three-platoon areas are established and in an extremely hostile area this can seriously reduce their effectiveness. Consequenty, tactical land clearing operations are often conducted in company mass. Figure 2-4 shows area clearing with tactical security forces deployed.

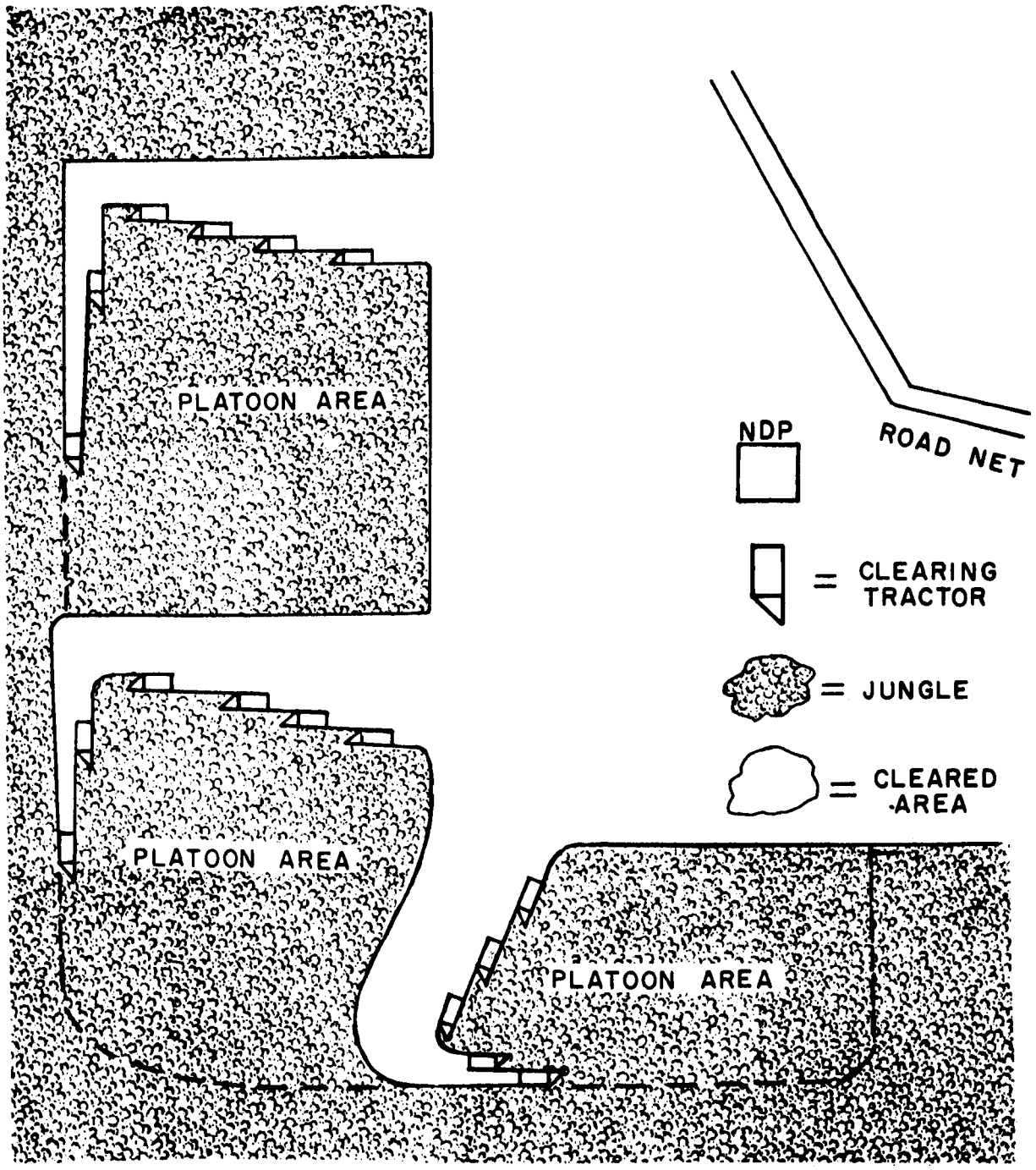
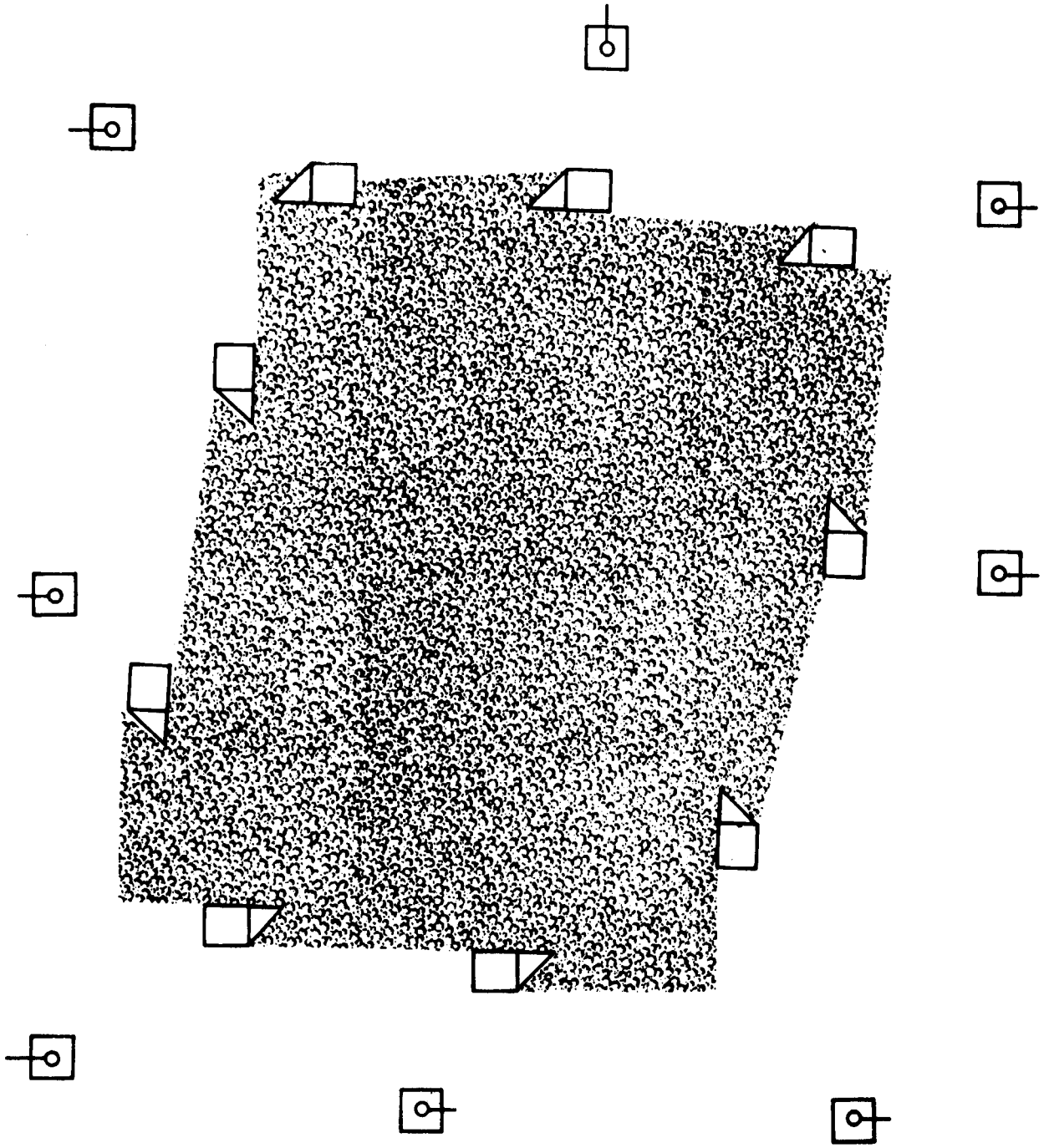
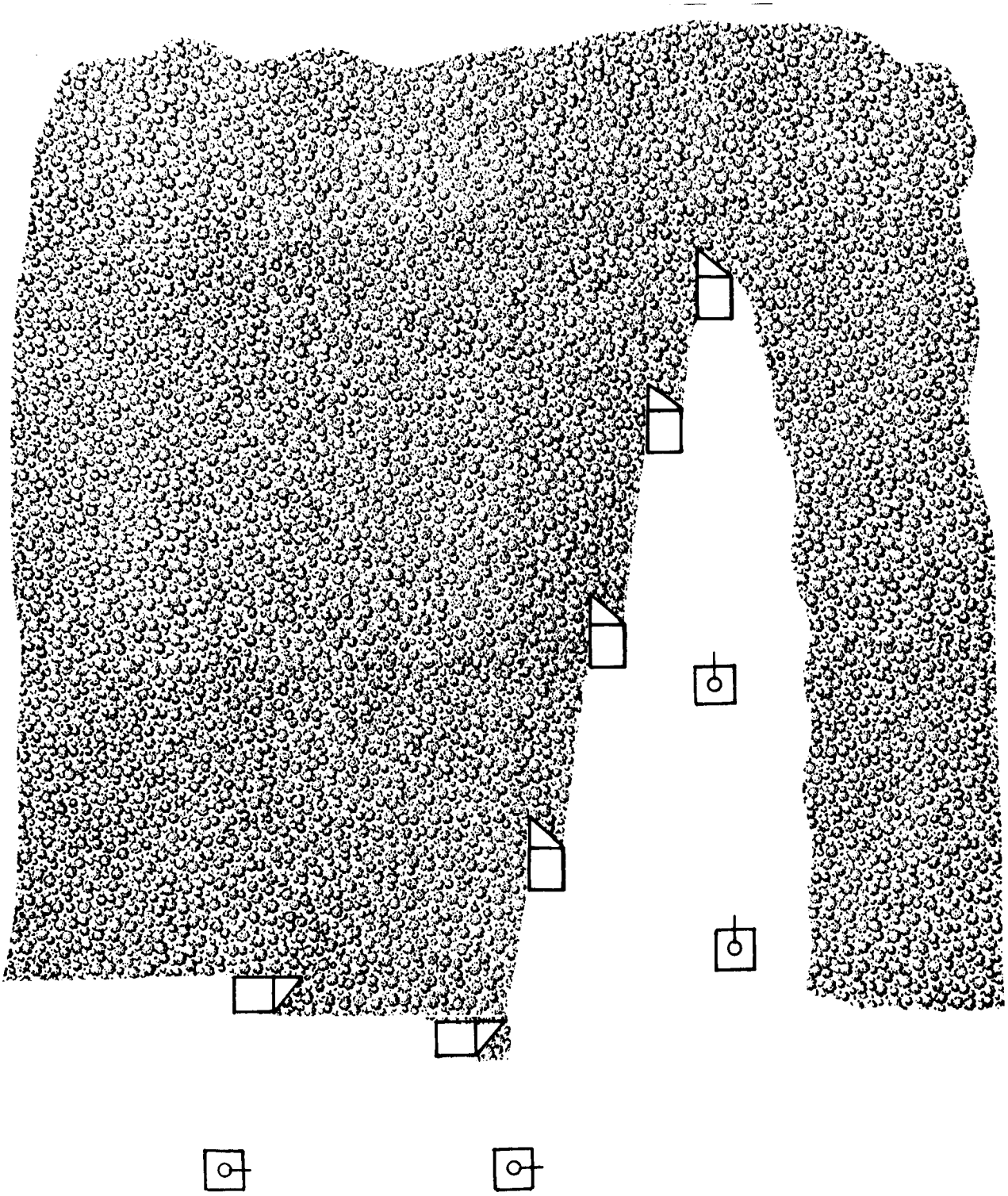


Figure 2-3 Typical area clearing (security elements not shown).



2

Figure 2-3. Strip clearing operation with security elements.



3

Figure 2-3. Clearing of land with mobile security defense elements.



Figure 2-4. Area clearing in a tactical operation.
Note. Isolated large trees are left standing.

b. Strip Clearing. This technique is used when clearing along roads and trails or when clearing surveillance lanes. One technique for strip clearing is to divide the land clearing company into two teams. The teams operate on opposite sides of the road, progressing at the same rate on both sides. If the strip is to be cleared is wide enough, clearing may be accomplished using an elongated rectangular pattern. When strip clearing along roads, another efficient technique is to cut from the road outward rat her than following rectangular traces on each side of the road. The tractors move in echelon left side of the mad, the lead tractor moving along the road shoulder. At midday the tractors cross the road and return down the other side of the road. Security forces have the advantage of interior lines and may move on roads and/or cleared areas to maintain positions of direct observation and protection over tractors and other elements of the land clearing force. When cutting a rectangular trace, the security force is stationed around a perimeter. Enemy forces are often trapped with the trace and the security force cannot fire heavy caliber weapons without endangering friendly troops on the opposite side of the cut. When the clearing tractors must cross the mad, care should be exercised to insure that drainage ditches and mad shoulders are not damaged.

c. Orchard and Plantation Clearing. The most efficient technique used in felling uniformly sized trees found in orchards and plantations is by use of an anchor chain pulled between two tractors. The production rate using this technique is considerably higher than shearing this type of vegetation. This technique is described in detail in paragraph 3-8 *f.*

2-9. Area Clearing Operations

a. Daily Work Area. The first step in organizing the cut area is to establish the daily work area. In a hostile environment alternates are also selected and these areas are shifted to keep the enemy from anticipating the location of the next day's cut. The complete area outlined should be cut in 1 day, because uncut islands of jungle openly invite the

enemy to employ mines or ambushes the following day. Areas which are difficult to clear and those in which the vegetation conceals a gully, stream, or other hazard, should be cleared first. By clearing these hazardous areas with the most experienced operators, the remainder of the area can be cleared by less experienced operators with little or no delay. These areas are often also the most likely avenues of approach for the enemy to move into the area to harass the operation. The tactical commander who has the overall responsibility for the operation, in conjunction with the land clearing unit commander, should select these areas and give them priority during the first part of the operation. When cutting heavy vegetation, the most efficient procedure is to bypass the large trees and engage only the undergrowth and smaller trees that can be pushed down in a single pass. A special team of skilled operators should be assigned to follow up and thin out the large trees as desired. If large trees are engaged in the initial pass, many tractors must sit idle while one operator works on a tree that he is unable to see clearly. Damage which may affect both tractor and operator under these circumstances can also be severe because of falling trees.

b. Maintenance Area. Upon arrival at the cutting area for the day, a secure area should be established for use as the onsite maintenance and assembly area for disabled tractors. An air compressor, water trailer, and contact maintenance vehicle will normally be placed in this secure area.

c. Trace Cutting. The initial trace of the perimeter for the day's cutting operation will be made immediatley after arriving at the cutting area. A lead clearing tractor will cut this trace counterclockwise around the perimeter, as shown in figure 2-3. Security is normally provided by combat units and/or combined arms elements; however, this is not shown in figure 1, 2-3. This lead tractor operator can easily become lost when cutting heavy vegetation because of limited visibility due to the undergrowth and trees falling back over the cab. When no trail or existing terrain feature exists to define the perimeter of the cutting area, the lead tractor should be guided by radio from an observation helicopter. In areas which contain streams, gullies, or other hazards, continuous aerial observation and control of the clearing tractors may be necessary. A lensatic compass can be used to assist the lead tractor operator in maintaining a course, but this is not as effective as radio control by an aerial observer, and normally would be used only in strip clearing. When cutting the initial trace, the security vehicles often are unable to follow in the path of the tractors because of the fallen trees. It is therefore essential that the lead tractor is equipped with a bulldozer blade that can clear the path for security elements. Only in very high jungle are security vehicles able to do without this assistance. Often, a pioneer road is necessary. If it appears that the cut originally outlined for the day's work is to be finished early, the commanding officer of the land clearing unit must notify the tactical commander a minimum of 1 hour prior to completion, to permit a timely arrangement for shifting security forces and the provision of aerial reconnaissance support for continuing clearing operations at the next scheduled cut or alternate cut. Cutting operations should be suspended at the close of each work day to allow sufficient time for the tractors to return to the NDP and have a minimum of 2 hours of daylight for maintenance of the tractors.

d. Bulldozer Support. When clearing in terrain which contains obstacles such as small gullies, streams, tunnels, or bunkers, some of the land clearing tractors should be equipped with bulldozer blades. These bulldozers should be used to do the earthmoving required to destroy the enemy installations, to construct pioneer roads in the cut for security vehicles, to build causeways across streams, and to fill gullies. They are absolutely essential for construction of fortifications in the night defensive positions. Do not attempt to use bulldozers in echelon with clearing blades when clearing large trees because they cannot maintain the cutting rate. The clearing blade should not be used for earthmoving purposes because it is less efficient and becomes dull so it will not cut trees effectively.

e. Cut and Piling Patterns. Clearing with an angled shear blade is conducted by the tractors of a land clearing platoon moving in echelon from the outside of the rectangular area toward the center in a counterclockwise direction. The cut sheds off the training (right) end of the blade and leaves the uncut area free of fallen debris. If the cut material will not shed, the operator should make a sharp right turn, followed by a sharp left turn and resume the original line of travel. The areas must be more carefully laid out if the vegetation is to be windrowed after felling. Piling is most efficient if windrows are oriented 90° to direction of cut. After the boundaries have been established by the initial trace, spoil areas for disposal and windrows are selected on the basis of the following factors: shortest haul, downgrade slope, and general accessibility. Care must be taken when locating windrows so as not to disrupt the natural drainage of the area. Vegetation windrows can form ideal concealment for the enemy if improperly oriented. Windrows should be placed perpendicular to the friendly perimeter so that both sides of the windrow can be observed. The windrows should also be perpendicular to the centerline of a

mad or trail that is used by friendly forces. All windrows restrict offroad manueverability of tactical elements so they should be burned or disposed of as quickly as possible. When the diameter and density of the vegetation is such that the tractor can move forward almost continuously, the most efficient production is obtained by laying out long areas 200 to 400 feet wide, clearing and piling the vegetation as shown in figures 2-5 and 2-6.

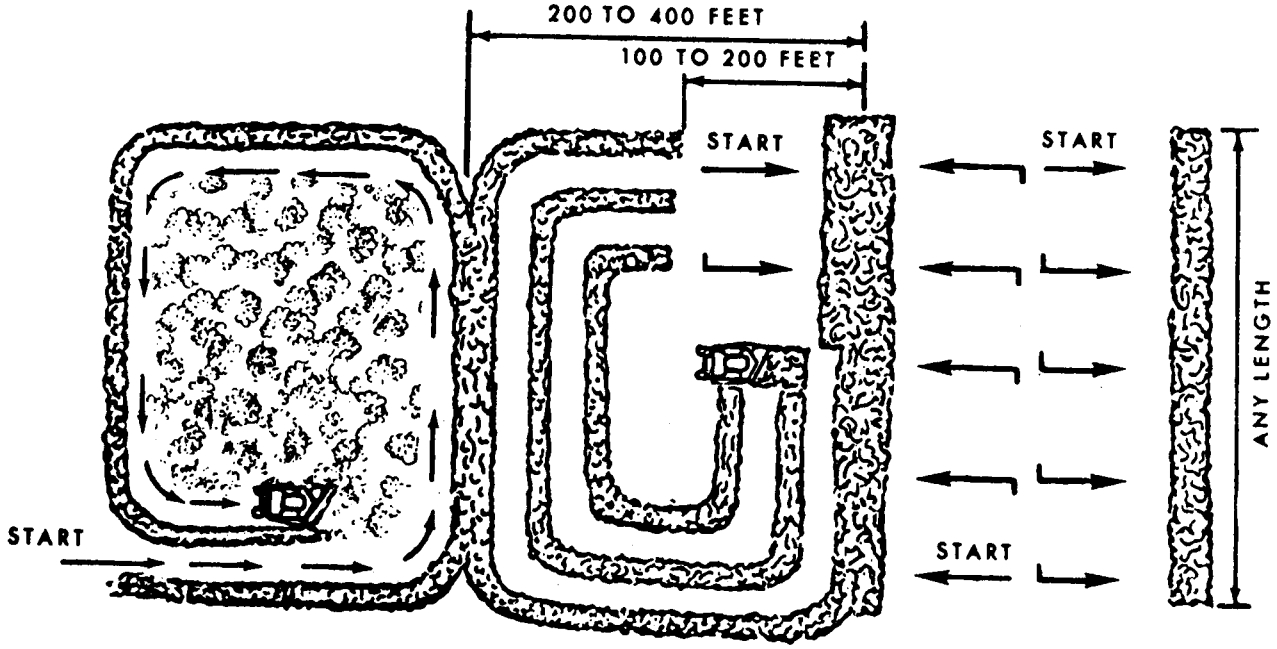


Figure 2-5. Cutting vegetation to ground level and piling cut material by counterclockwise method.

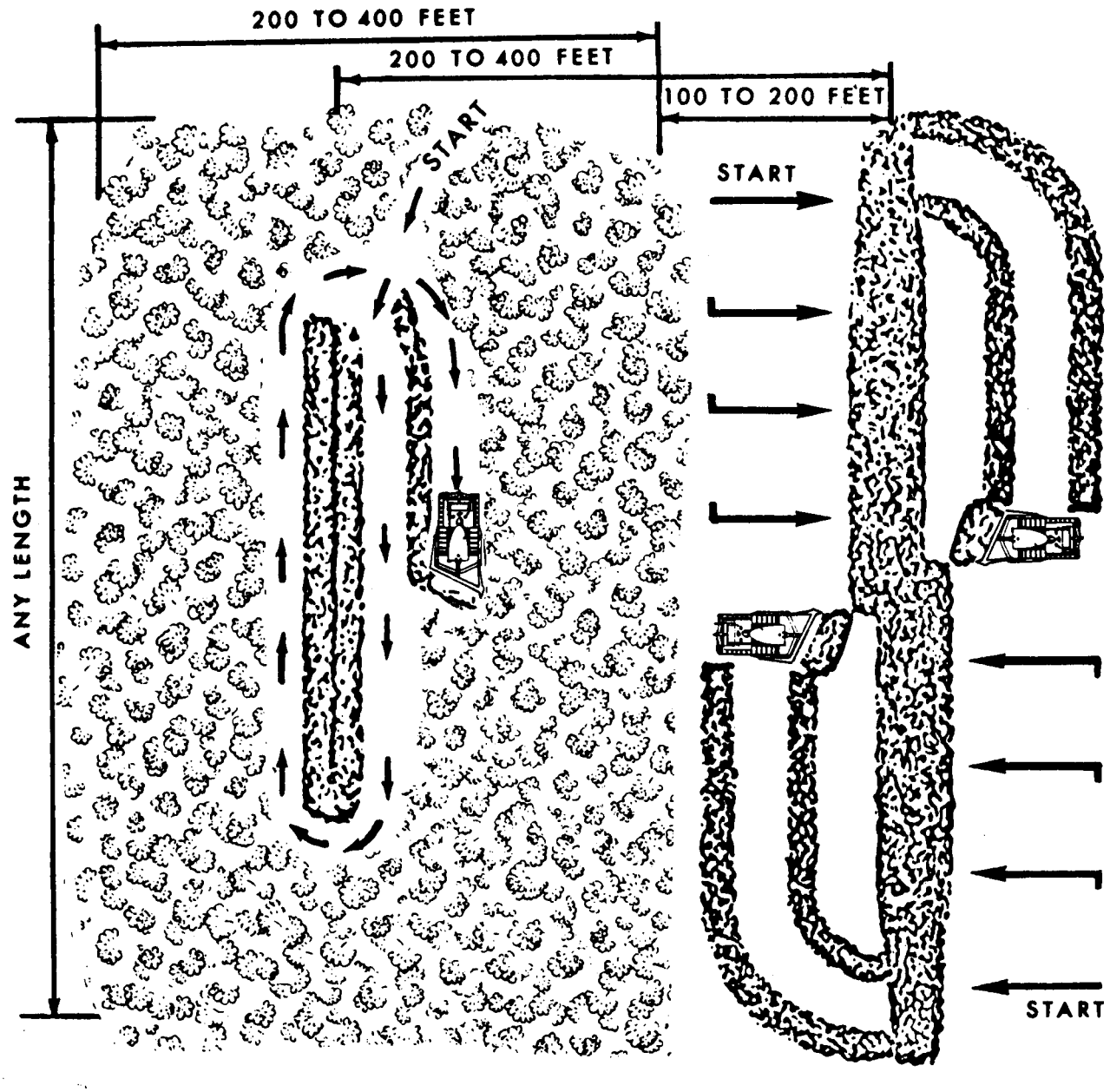


Figure 2-6. Cutting vegetation to ground level and piling cut material by the increasing rectangles method.

These methods are the best for most relatively level areas. On steep slopes, rapid production is obtained by working in a semicircular pattern from left to right, pushing the vegetation downslope (fig 2-7). If the terrain is steep the windrows should be piled on the contours and the tractor should work from the uphill side. On level terrain, if the vegetation is dense and small as in light brush, highest production can be obtained by cutting and windrowing simultaneously. By working counterclockwise in increasing rectangle, with the trailing edge of the blade working against the uncut material, the operator can prevent the cut material from sliding off the blade and allow the cut material to accumulate on the blade. When the blade is filled, the operator stops the tractor, deposits the cut material, forming a windrow, then turns to the left twice to the starting point and repeats the operation, as shown in figure 2-8.

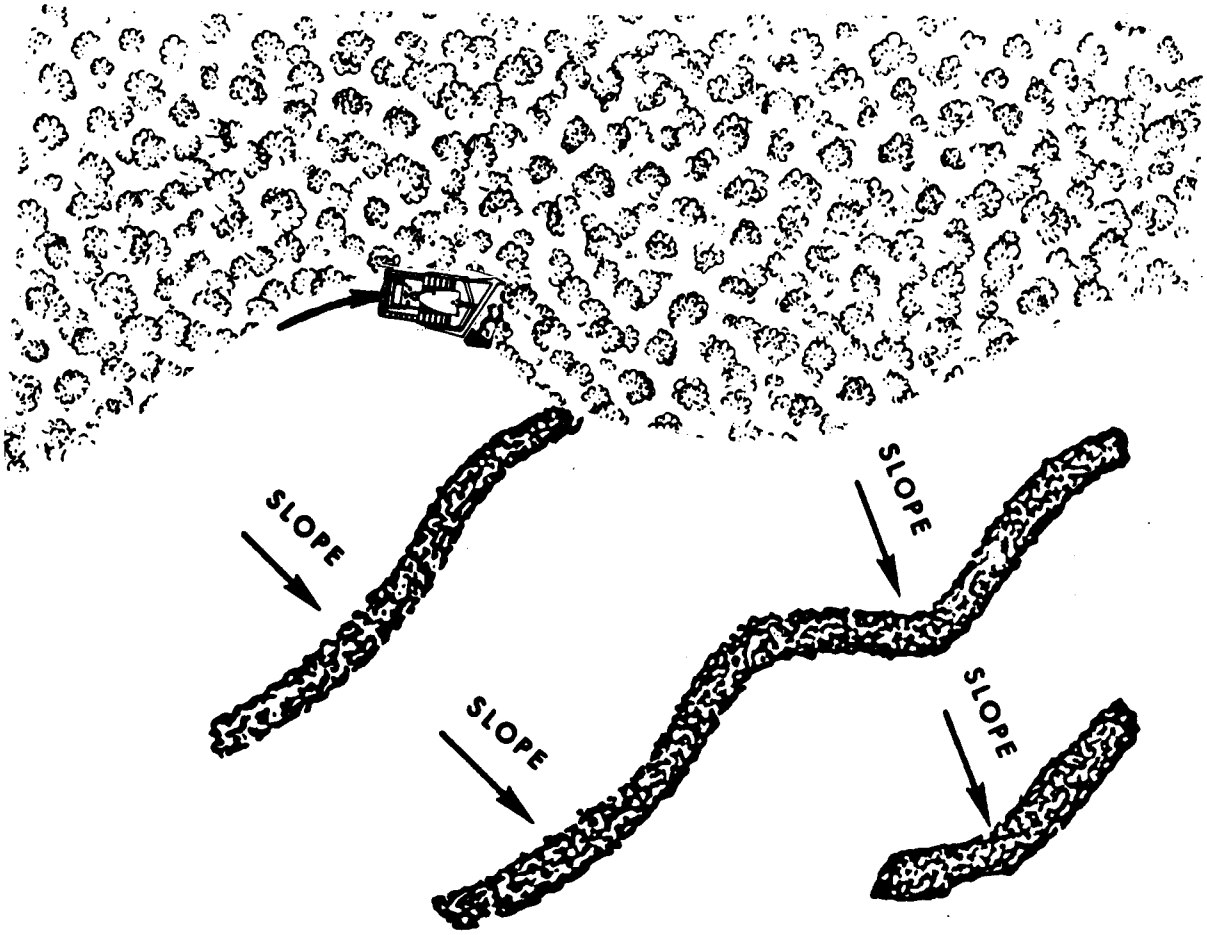


Figure 2-7. Clearing on steep slopes.

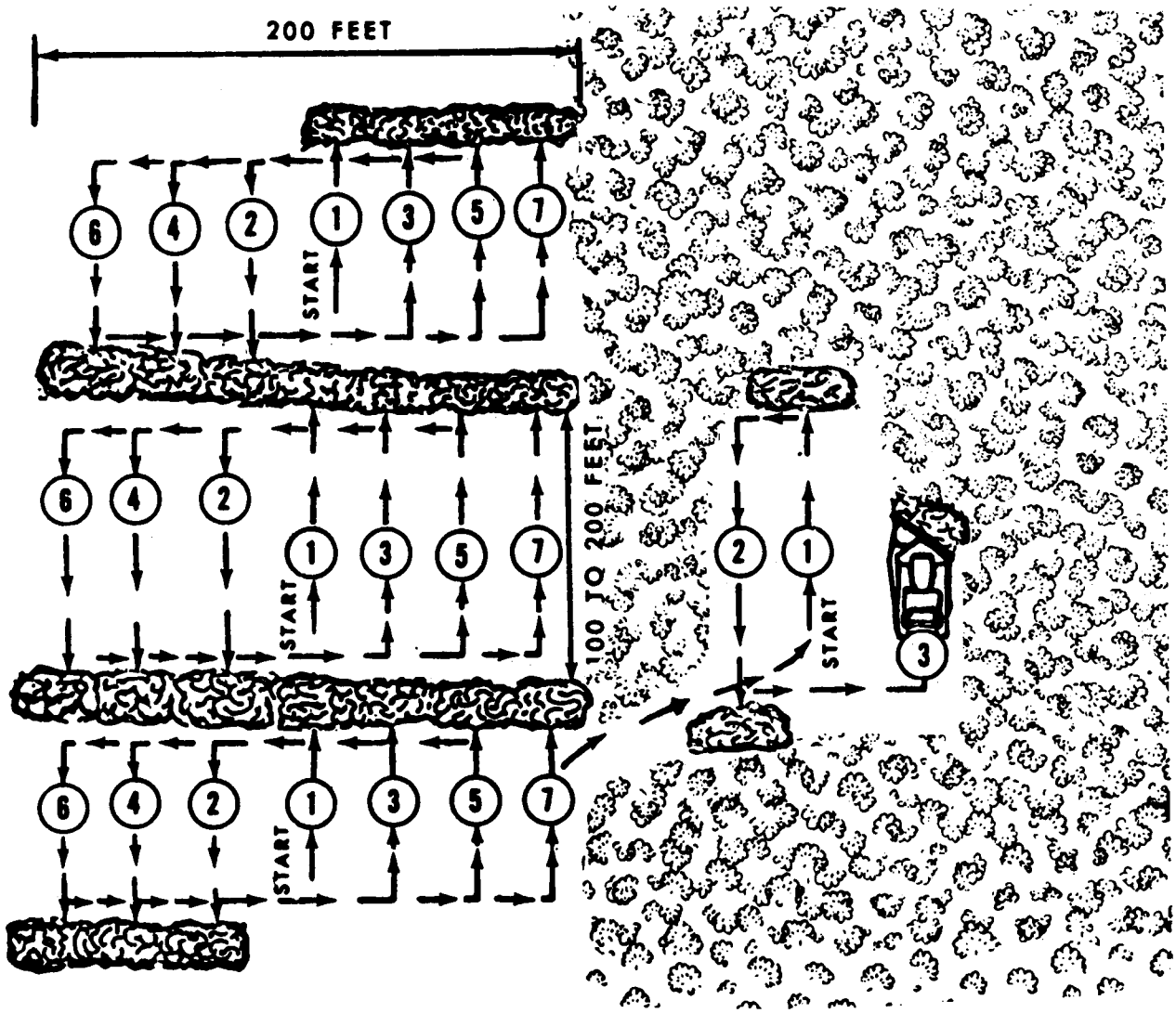


Figure 2-8. Cutting and piling dense growth of small diameter vegetation on level terrain.

This technique reduces the time spent backing up. All of these methods of piling are 20 to 30 percent faster with three to five tractors working abreast. The tractors should work close together when piling the vegetation to obtain this increased efficiency, but when clearing, the tractors should be a minimum of 30 meters apart to preclude felling trees on each other, colliding due to limited visibility, or increasing casualties due to a mine or boobytrap. See figure 2-9 for a typical fleet operation.

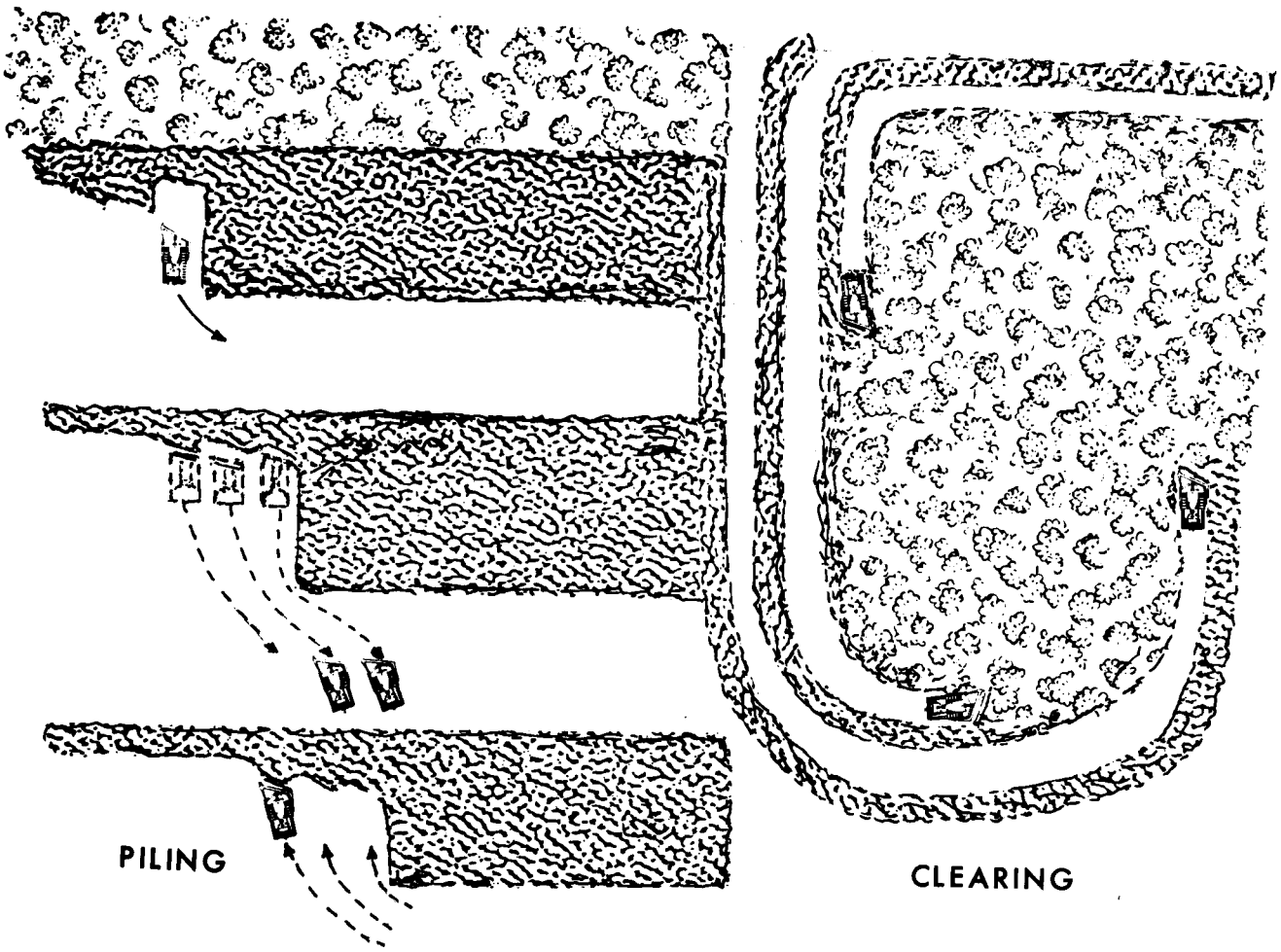


Figure 2-9. Fleet operation.

f. Chopping and Disking Patterns. There are two basic patterns used when clearing growth with a rolling chopper or disk harrow, as shown in figures 2-10 and 2-11.

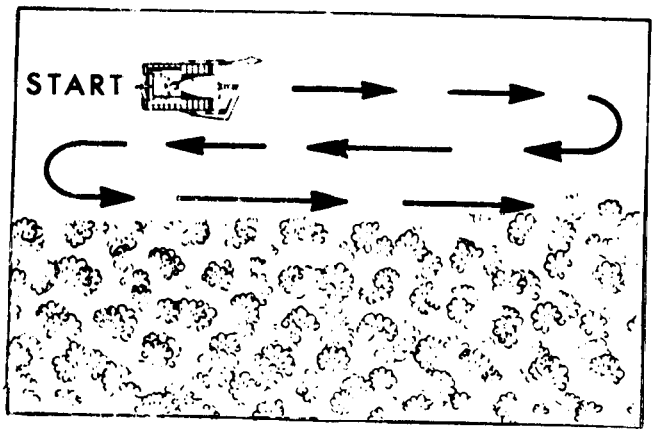


Figure 2-10. Parallel cuts.

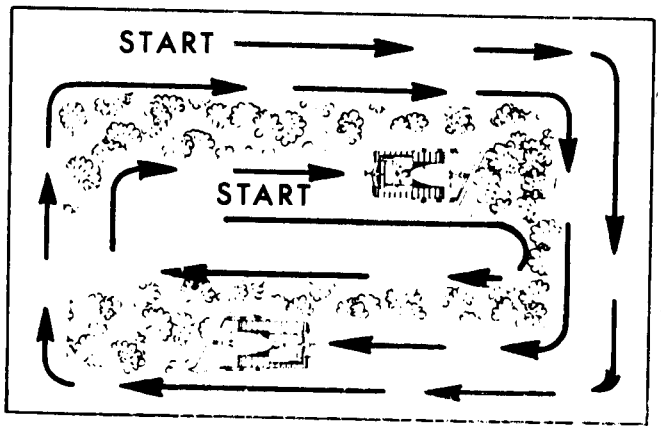


Figure 2-11. Increasing or decreasing rectangles.

Variations of these two basic methods are made to fit the topography or shape of the area being cleared. When cutting poles, bamboo, or large saplings, the reccommended procedure is to cut in the same direction as the previous pass using increasing or decreasing rectangles.

2-10. Strip Clearing Operations

The first phase of a typical route or strip clearing

operation is to establish an NDP about 4 kilometers beyond the last cleared area, as illustrated in figure 2-12.

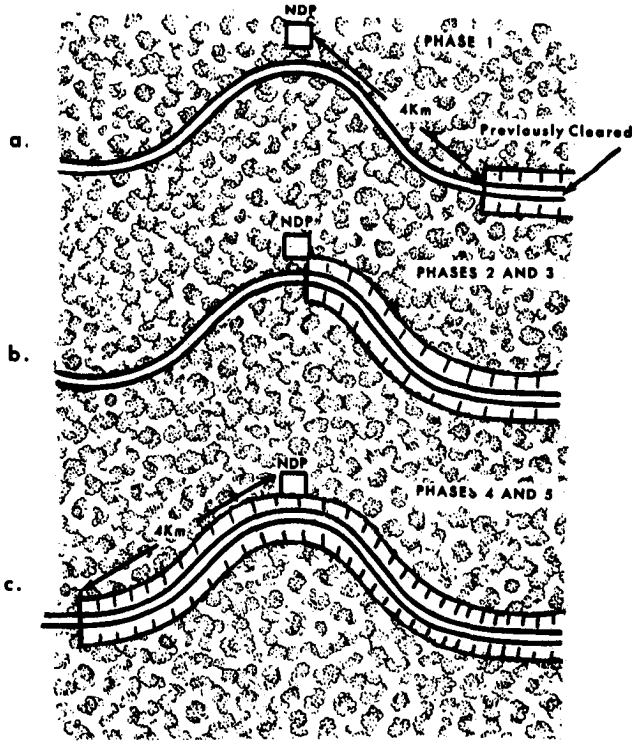


Figure 2-12. Route clearing.

The land clearing unit then clears back toward the NDP and about 4 kilometers beyond. A new NDP is then established 8 kilometers farther down the road. Along roads or major trails the vegetation is cleared 200 meters wide on each side of the road. If the strip clearing is to establish observation and reconnaissance lanes, these cleared strips are from 200 to 500 meters wide. Fallen trees are normally piled when clearing is adjscent to major roads. The windrows are piled perpendicular to the road so they cannot be used as cover by the enemy (fig. 2-13). The end of the windrow adjscent to the uncut vegetation should not extend to the forest, but should stop 10 to 15 meters short to allow reconnaissance and security vehicles to pass around the end of the windrows adjscent to the uncut forest.



Figure 2-13. Aerial photo of route clearing.

2-11. Clearing Cultivated Areas

Cultivated areas such as rubber plantations and fruit orchards are most efficiently cleared by chaining. The organization of the area is dependent upon the size and shape of the plantation. When chaining is used as a clearing technique it is preferable to organize the pattern of the cut so the tractors can make as long a pass in one direction as possible because turning or reversing direction with a chain results in considerable lost time. A pattern similar to that used in chopping or disking (fig. 2-10 and 2-11) should be used.

2-12. Clearing Rates

The following are average estimates for a clearing operation of one land clearing company with 25 operational medium clearing tractors for various types of cuts under optimum conditions of security and level, dry terrain, excluding windrowing.

a. Area Clearing.

(1) Light (less than 12 inches diameter)	400 acres / day
(2) Medium (12 to 20 inches diameter)	250 acres / day
(3) Heavy (greater than 20 inches diameter)	100 acres / day

b. Strip Clearing.

(1) Light (less than 12 inches diameter)	250 acres / day
(2) Medium (12 to 20 inches diameter)	150 acres / day
(3) Heavy (greater than 20 inches diameter)	100 acres / day

c. Cultivated Rubber Using One Land Clearing Platoon With Three Anchor Chains.

(1) Light (less than 6 inches)	400 acres / day
(2) Medium (less than 12 inches)	250 acres / day
(3) Heavy (greater than *12* inches)	100 acres / day

These production rates are subject to considerable variance due to tactical and terrain conditions and should be used for general planning estimates only.

CHAPTER 3

CLEARING METHODS AND TECHNIQUES

Section I. BASIC CONSIDERATIONS

3-1. General

Before selecting the equipment and personnel needed to complete a land clearing project, and prior to any estimation of the time required, certain factors must be considered. These factors include the reason for or purpose of clearing the land, the size and shape of the area, the location of the project, the time available to accomplish the work, and the terrain (see app F for information on terrain intelligence considerations).

3-2. Purpose of Clearing

The stated or implied purpose for accomplishing a given land clearing mission has considerable bearing on the specifications or standards to be attained. In tactical land clearing, the primary objective is to enable tactical units and weapons to destroy the enemy, to force him out of the region, and to make key areas unable to be defended. Accordingly, tactical land clearing is highly selective and usually aimed at denying cover to the enemy for a limited period. In construction clearing, normally the purpose is is remove all the surface and subsurface vegetation to facilitate a construction project. Sometimes the long and short range use of the land by other than military forces is a factor which should be considered in selecting the clearing method used. The specifications must define the purpose of clearing and the finished conditions clearly. Care should be taken to specify only those conditions that are absolutely essential, because considerable extra time and effort may be expended on work that is unnecessary. Details on specification writing and clearing requirements are contained in the chapters on tactical and construction clearing.

3-3 Scope of the Project

The size of the area will obviously have a direct bearing on the amount of equipment which should be employed m the area. The shape and topography of the area must also be considered. Long narrow strips or areas adjacent to roads require different cutting and disposal techniques than larger rectangular areas. Small areas such as landing zones and fire support bases are special cases and will be discussed in chapter 4.

3-4. Location of the Area

The proximity of the area to be cleared to the land clearing unite base area must be considered, not only for the transportation required at the beginning and completion of the project but for resupply and maintenance support throughout the project. The location of the nearest maintenance service facility to which deadlined equipment can be evacuated and the location of the parts supply unit have considerable impact on the time required to get inoperative equipment repaired and back to work.

3-5. Time Available

Another important consideration is the time schedule for completing the project. Frequently this is dictated by other considerations such as concurrent tactical combat operations in or near the area to be cleared at the time that clearing equipment can be released from other tasks. Weather has a marked effect on the time available. When a low-lying area must be completed prior to the rainy season or an approaching storm, the duration of the project may determine its success or failure.

3-6. Other Factors

Consideration of enemy activity within the area to be cleared and the enemy capabilities can be significant factors in planning an operation. These aspects were discussed in chapter 2. The condition of the clearing equipment, the maintenance posture and capabilities, and the status of training of the personnel will also have to be considered when planning the operation. Maintenance will be discussed elsewhere in the manual.

Section II. METHODS AND EQUIPMENT FOR INITIAL FELLING

3-7. Introduction

There are several methods for initial felling and many types of equipment which can be used with each method. This section includes a discussion of the mechanical methods and related equipment which are currently available within the Army inventory, as well as a limited discussion of several special purpose items of land clearing equipment which can be procured for use for specific operations or types of vegetation. The use of explosives, hand clearing, and burning will also be discussed. The selection of the methods and equipment, and the advantages and disadvantages of each, are dependent upon many variables which must be considered individually for each clearing situation.

3-8. Uprooting Vegetation

Several types of equipment are used in this method of clearing. These include bulldozer blades, rakes, knockdown beams, root plows, spade plows, and anchor chains drawn between two large crawler tractors.

a. Bulldozer Blades. Until recently, the most common method of clearing land was by utilizing the crawler tractor with its ordinary straight or angling bulldozer blade (fig 3-1). Even though 30 to 40 percent more land can be cleared utilizing specialized land clearing tools, the bulldozer can be efficiently used in small and intermediate sized areas where it is readily available and specialized land clearing equipment is not. When larger trees which cannot be pushed over are encountered they must be dug out of the ground, a time-consuming operation (fig 3-2). Small trees and bushes are often so flexible that they bend over as the dozer blade passes over them, and may not be removed unless the roots are also removed. Since a ball of dirt is often left on the roots of the tree when it is uprooted, subsequent disposal, especially by burning, is made more difficult. A recent improvement of the straight bulldozer blade has been the development of the hydraulically actuated tilt cylinder. This allows the operator, from the seat of the tractor, to tilt one comer of the blade to facilitate cutting of lateral tree roots for easier felling. The bulldozer is not the best tool for piling felled vegetation because it takes too much soil into the windrow with the cut vegetation, which retards the burning process.

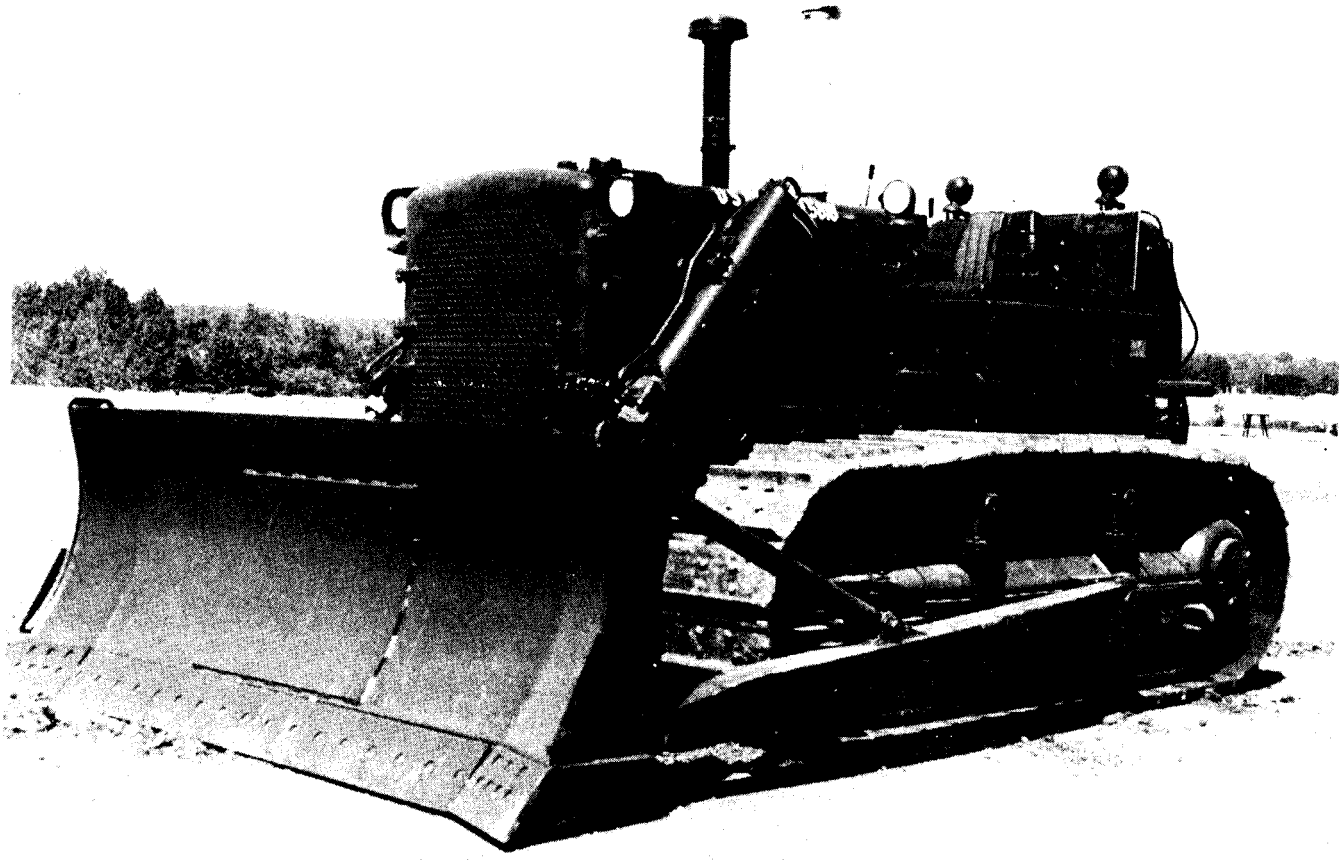


Figure 3-1. Medium crawler tractor clearing with bulldozer blade.

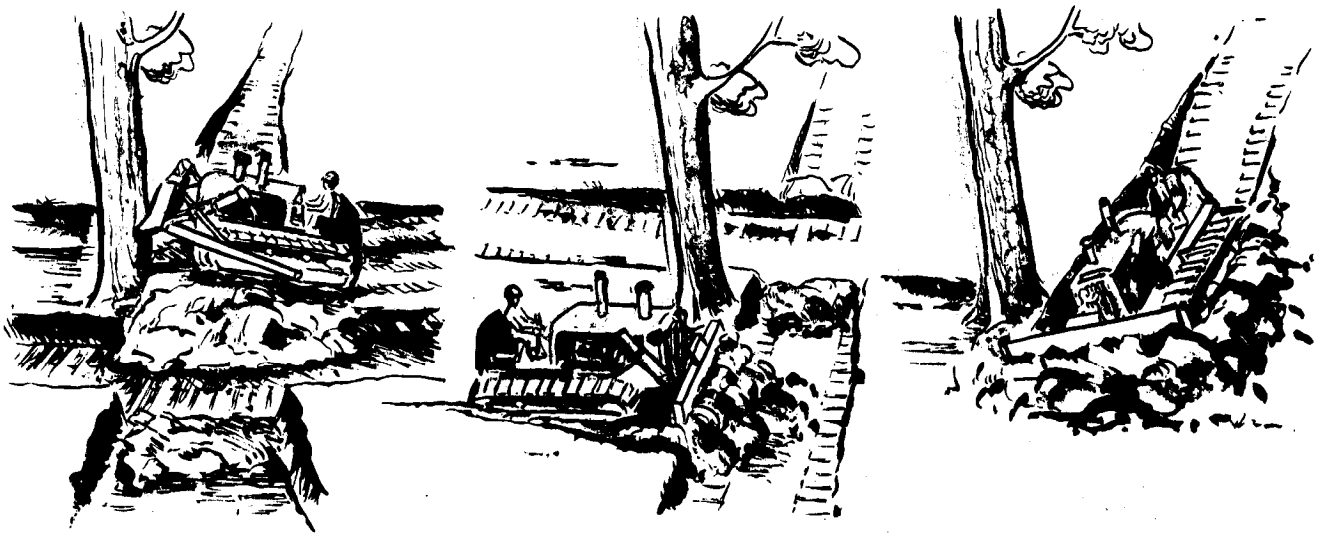


Figure 3-2. Tree removal be excavation.

b. Rakes. Rakes of various specialized types can be mounted on or in place of a bulldozer blade and utilized for clearing of both trees and rocks (fig 3-3). Rakes have the advantage of allowing most of the soil to pass between the teeth as they are pushed through the soil. They can be used for uprooting vegetation and piling rocks, stumps, and cut vegetation into windrows. Rakes work exceptionally well in sandy soils and in rocky soils that would damage a shearing blade. Rakes do not work well in wet cohesive soils because of the clogging of the soil between the rake teeth. When this occurs, the rake is in effect converted to a bulldozer blade with all the inherent disadvantages. Many different types of rakes are manufactured for track-type tractors. Each size, weight, and strength has a particular application, and care must be exercised to insure that each type is used only for the purpose for which it was designed. Listed below are some of these rakes and their application.

Rake	*Application*
Multi-application rake (fig. 3-3)	All heavy duty land clearning including tree and rock removal.
Rock rake	Clearing and grubbing boulders, spreading rock riprap, and grubbing and piling stumps and debris.
Blade rake (fig 3-4)	Light grubbing, piling, and raking .
Brush and cleanup rake (fig 3-5).	Final cleanup after initial clearing.

Rakes are used very successfully and are recommended for repiling burned or burning material, since the ash residue and soil can sift through the teeth and cleaner, hotter burns can be achieved. More discussion on the use of rakes in burning is included in Paragraphs 3-21 through 3-26.

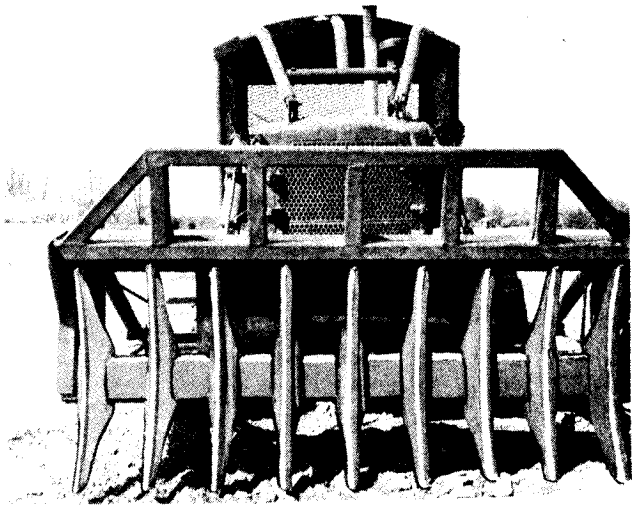


Figure 3-3. Multi-application rake.

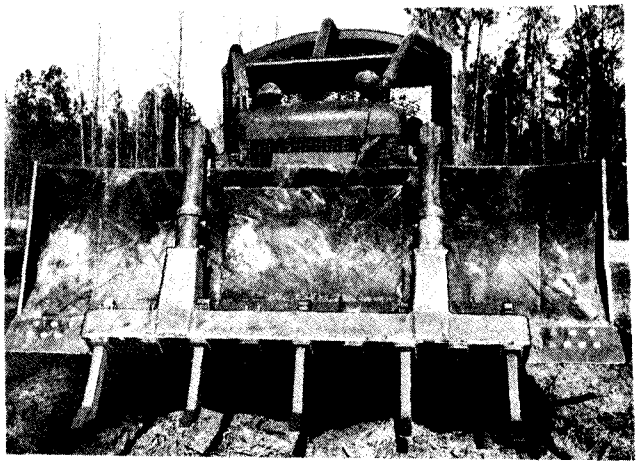


Figure 3-4. Blade rake (H & L brush grubber).

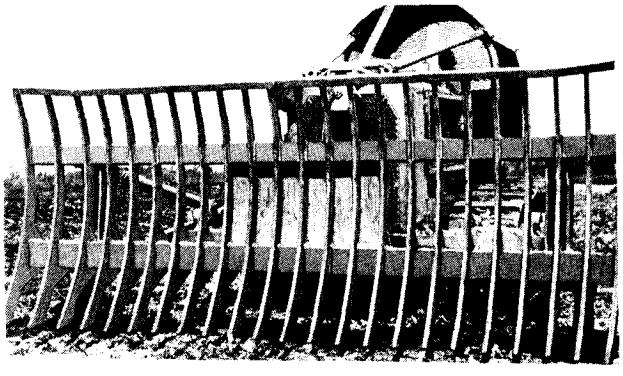


Figure 3-5. Brush and cleanup rake.

c. Knockdown Beams. Both bulldozers and rakes depend on the brute force of the tractor to uproot the vegetation. This same principle applies, in part, to the knockdown beam (fig 3-6), which is a structure extending above and forward of the tractor to give the tractor added leverage in pushing over larger trees. They are ideal when used in combination with some device for cutting the roots around larger trees such as a rooter, allowing the trees to be pushed over with greater ease. Knockdown beams can also be used in conjunction with anchor chaining by lifting the chain higher on larger trees for increased leverage and pushing against the larger trees to assist the chain. The effectiveness of this tool is impaired if the trees are too large, taproots are present, or traction is poor. Knockdown beams are uneconomical for use on small diameter trees or brush. This makes the knockdown beam a highly specialized tool with limited application to specific land clearing situations.



Figure 3-6. Medium sized tree being felled with a knockdown beam-bulldozer blade combination.

d. Root Plow and Grubber. The root plow is a tool for removing vegetation by cutting it below the soil surface (fig 3-7). It is designed for killing brush and light vegetation by undercutting it at or below the crown or bud ring at depths from 20 to 50 centimeters (8 to 20 inches). Large roots are forced to the surface by the fins on the horizontal blade (fig 3-8). Root plows are available for mounting on tractor trunnions or tool bars. The advantage of the root plow is that it cuts the vegetation below the bud ring, killing brush that would normally resprout if cut at ground level. The disadvantages of the root plow are that the size of vegetation it can cut is limited and that it does not work well in sandy or rocky soil. The grubber is a smaller version of the root plow and is normally mounted on a wheeled tractor to clear small clumps of brush. It has the same advantages and disadvantages as the root plow, but can move quickly from one clump to another.

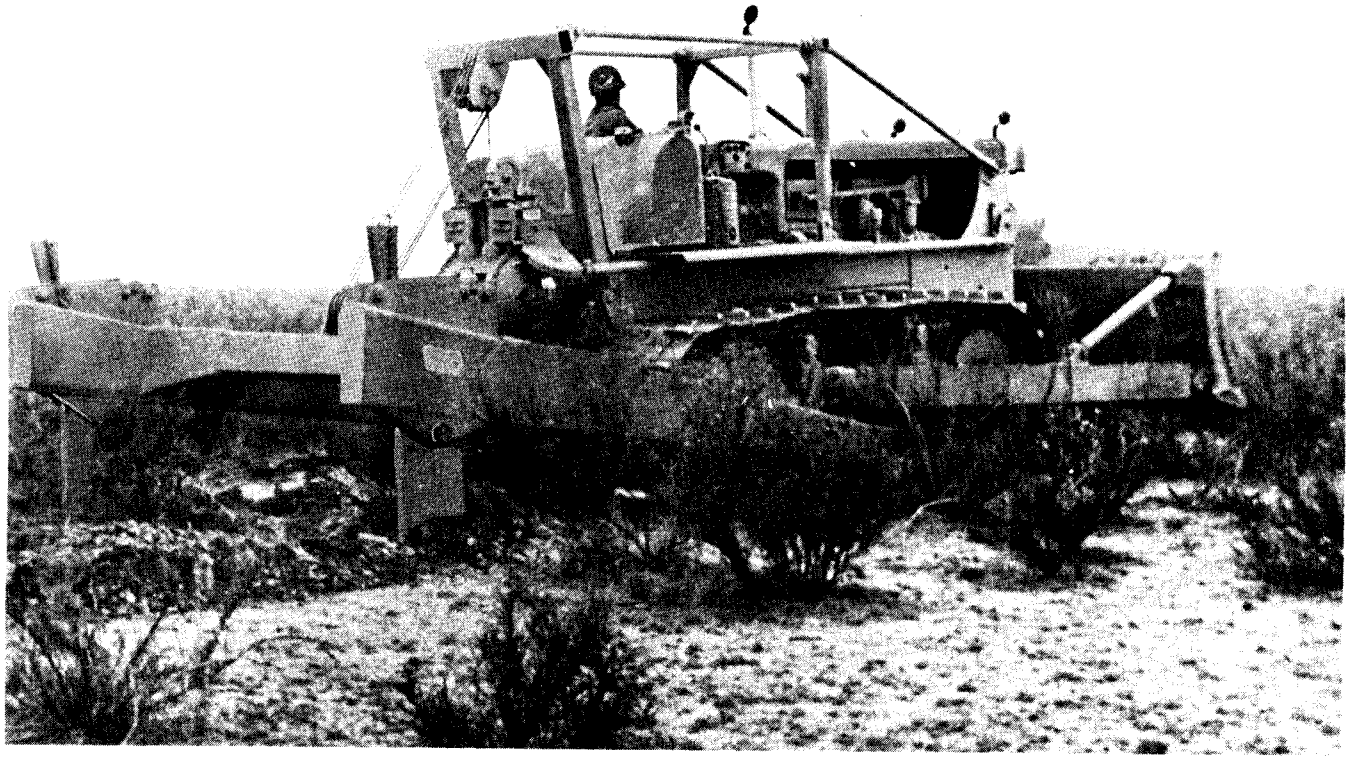


Figure 3-7. Trunnion-mounted root plow.

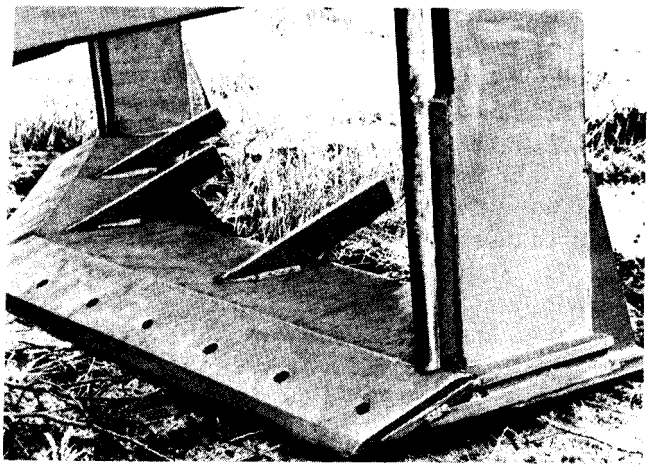


Figure 3-8. Root plow. Note the fins which force large roots to the surface.

e. Spade Plow. A relatively recent development is a universal land clearing tool called the spade plow (fig 3-9), which is capable of removing entire trees, including roots. The spade plow is a combination rake and root plow, which also incorporates a horizontal knockdown beam to increase leverage for uprooting larger trees. The heavy duty cutting blade mounted between the teeth on the lower part of the spade plow shears light vegetation at or below ground level, while the knockdown beam pushes over and uproots the larger trees. It has the advantage of being applicable to many uses without changing attachments, and is especially effective in stacking and piling debris for disposal in soil-free windrows. The cutting blade may also be used to cut strips of turf for covering (sodding) bare areas. Sodding controls erosion, provides soil stability (including dust control), and serves as camouflage material. The disadvantages are that it is limited to medium sized trees and it will not perform well in heavily wet soils.

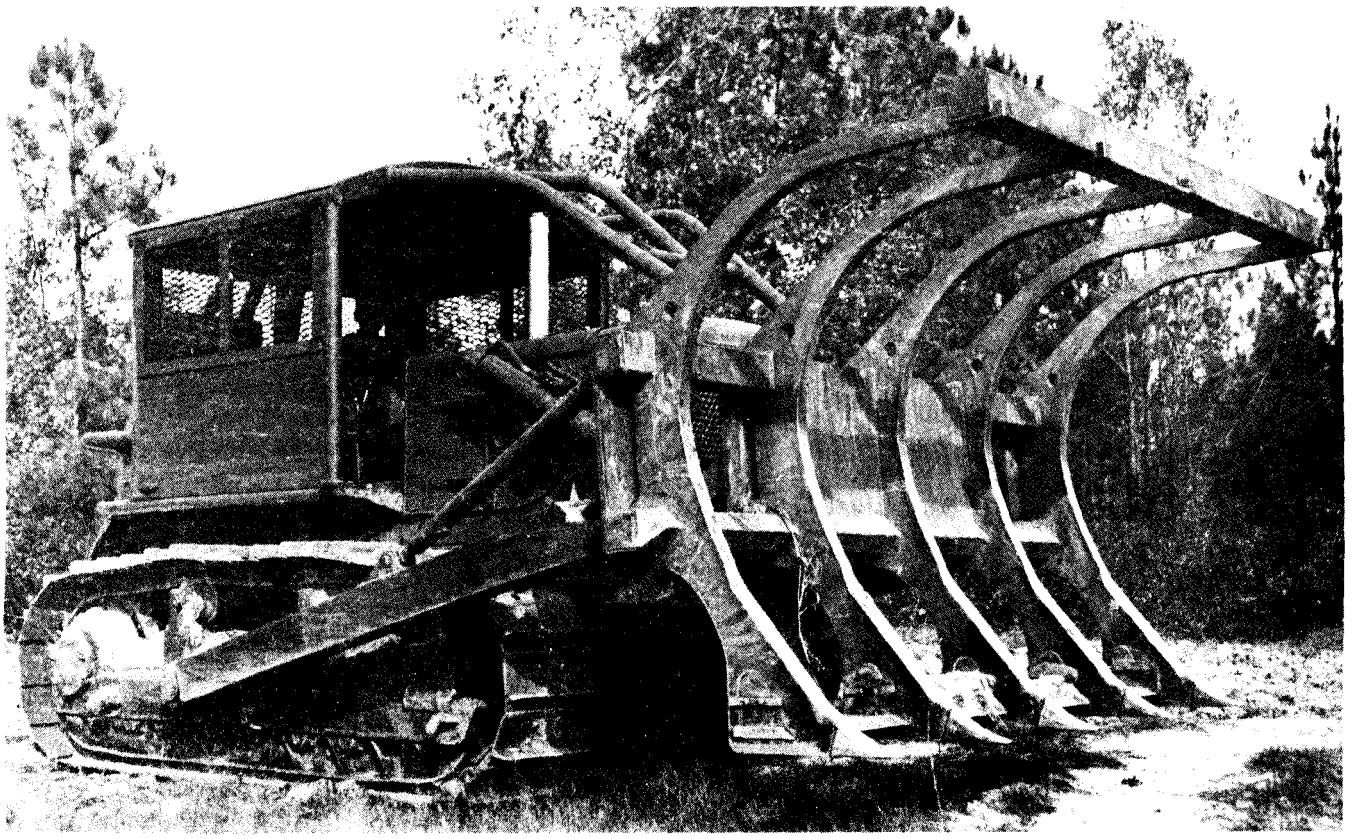


Figure 3-9. Spade plow. Note horizontal knockdown beam on top and cutting blade on bottom.

f. Anchor Chains and Large Crawler Tractors. Chaining is a highly effective method of felling vegetation in some large-scale clearing operations (fig 3-10). Experience has shown that chaining can be used in all sizes of vegetation. The upper limit in vegetation size and density will vary with the size tractors used, the tractive conditions, and the width of swath chained. The terrain should be level to gently sloping without large gullies, stone outcropping, or other obstructions preventing free passage and maneuverability of the tractors and chain. There should be sufficient straight length of pass to minimize turning around with the chain, a time-consuming operation. Short range two-way radios with headsets facilitate communication between the two tractor operators. A third tractor may often follow the chain to lift it over obstructions and to assist the chain when occasional oversized trees are encountered. The tractor operator should follow at a safe distance to preclude injury to the tractor operator or damage to the tractor in case of tree backlash. Chain size and length depend upon tractor size and the vegetation to be cleared. As a rule of thumb, the length of the chain should be three times the operating distance between the tractors, and two-and-a-half times the height of the tallest tree. If the tractors operate 61 meters (200 feet) apart, the chain should be 183 meters (600 feet) long. Swivel-eye-and-socket links can be installed along the chain if twisting is a problem. These swivels should be placed one at each end and two within the length of the chain at the point where the loop starts to form. The diameter of the steel in the chain link should be sufficient to provide the strength and weight to operate safely even after considerable wear. The following chain sizes have been used successfully:

Tractor size	*Link steel diameter*	**Approx. wt/ft**
180 hp	5.1 cm (2 in)	17.0 kg (37.5 lb)
270–385 hp	6.4cm (2.5 in)	27.2 kg (60.0 lb)
385 hp	7.6cm (3 in)	39.7 kg (87.5 lb)

One or more metal balls–solid steel, hollow steel, or hollow steel filled with concrete-may be used to give the chain greater weight and impact (fig 3-11). These balls are connected at or near the middle of the chain with universal connectors. When more than one bell is used, they should be equally distributed in the central half of the chain. These balls help the chain conform to the terrain on gentle to moderately steep grades. They are especially useful when the chain is used to clear and span narrow, wet valleys. Balls are not needed on level terrain where the size of the vegetation does not require the added weight.

Typical sizes and weights of balls in use are as follows:

Diameter	*Type material*	*Approximate weight*
.9m (3 ft)	Cast iron	2950 kg (6,500 lb)
1.1m(3½ ft)	do	4540 kg (10 ,000 lb)
1.2m(4ft)	do	6810 kg (15,000 lb)
1.2m (4 ft.)	Concrete filled steel shell	2500 kg (5,500 lb)
1.5m(5ft)	do	4540 kg (10,000 lb)
1.8m (6 ft)	do	7490 kg (16,500 lb)
3.0m (10 ft)	do	6810 kg (15.000 lb)

The chain is dragged behind two crawler tractors (fig 3-10). The outside tractor travels along the edge of the uncleared area and the inside tractor travels through the uncleared area avoiding any large vegetation. The distance between the tractors will vary with the size of the tractors, the traction, and the size of the vegetation. The width of the swath should be narrow enough that the tractors can travel almost continuously in a forward direction. A rule of thumb that is used to determine if chaining is more economical than having the tractors operate individually is as follows: if the two tractors can maintain a constant forward motion clearing a swath that is seven times their blade width or greater, chaining is the best technique. The width of the swath may be 12 times the blade width. However, a third tractor is needed to follow to assist the chain. Figure 3-12 shows a third tractor with a bulldozer blade following the chain to assist in uprooting larger vegetation. Two passes in opposite directions may be required to uproot areas with smaller diameter vegetation which only bends over on the first pass. Chaining proved to be extremely effective in clearing rubber plantations in Vietnam where uniform diameter trees and little or no undergrowth were encountered. Chaining has also proved to be a satisfactory technique when clearing bamboo hedgerows in some geographical areas of Vietnam.



Figure 3-10. Two large crawler tractors towing anchor chain into clearing position.

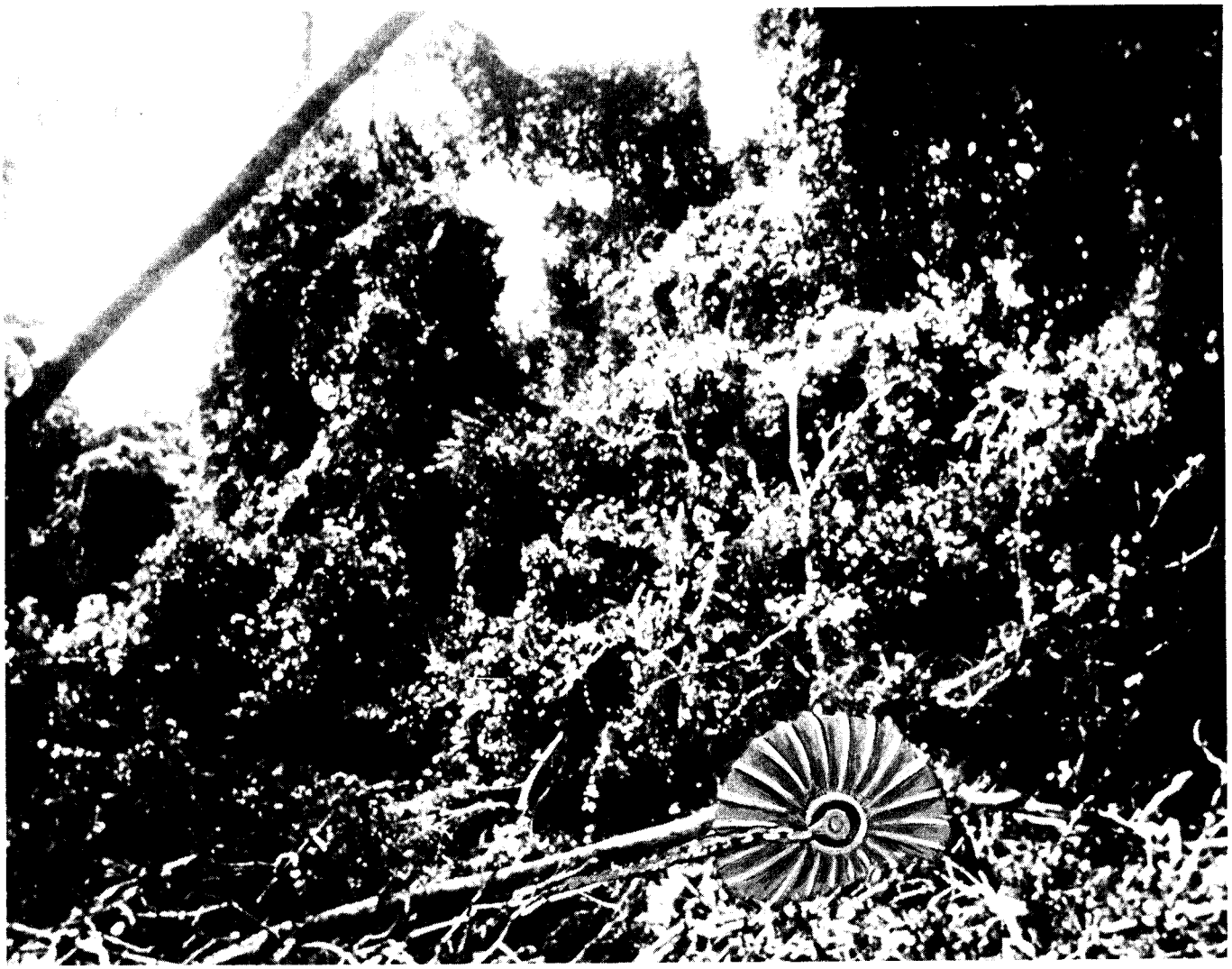


Figure 3-11. Jungle being cleared using two tractors, chain, and a 10 ft diameter steel ball.



Figure 3-12. Third tractor following the chain to assist on larger vegetation.

3-9. Cutting or Shearing Vegetation

This method varies from uprooting the vegetation in that the growth is cut off at or slightly above ground level, leaving the stumps in the ground to decay or to be removed later. The tools used for this type of clearing probably vary more than any other method (TM 5-342). They range from a hand axe or machete at one extreme, to a large crawler tractor equipped with a shearing blade on the other. This technique is especially effective in large vegetation where the brute force of the tractor is insufficient to uproot the vegetation without digging around it. In areas of heavy rainfall, cutting the vegetation at ground level does not cause the large holes in the soil that uprooting does, therefore the natural drainage of the area is not inhibited.

a. Handtools. Handtools such as axes, brushhooks, machetes, grubbing hoes, and pick-mattocks are generally adequate for small areas and areas inaccessible to heavy equipment. They may also be suitable when ample manual labor is available and time is not critical.

b. Chain and Crosscut Saws. In larger diameter vegetation, chain saws or crosscut saws are more suitable for use than axes or similar tools. Crosscut arid chain saws are available in most engineer units (fig 3-13, 3-14). Chain saws are available in lengths from 2 to 5 feet and are either electric, pneumatic, or gasoline-engine driven. Sawing a tree is accomplished by a single cut, or on larger trees by a series of cuts. The first step in cutting a tree is to determine the direction of fall. A tree should not be felled so as to become lodged in the branches of another tree. Once the direction of fall is determined, the next step is to clear away brush and low-hanging branches which will interfere with the use of the axe or saw. The first cut made on a large tree is the undercut which is made on the side toward which the tree is to fall. The undercut is made using two cuts, one horizontal and one at 45 degrees, to a depth of

about one-fourth of the diameter of the tree (fig 3-15, 3-16). The backcut should then be made from the opposite side of the tree approximately 2 inches higher than the bottom of the undercut. The cut should be kept parallel with the undercut until only 2 or 3 inches of holding wood is left. If the tree has not fallen by this time, it should be tipped by driving one or two felling wedges behind the saw. Extreme care should be taken to insure that the saw is not caught at the hinge when the tree starts to fall. The saw should be pulled back toward the wedge, or completely out of the cut if possible, as soon as the tree starts to fall. If a cut tree lodges in a standing one, a dangerous condition can exist. Providing the tree is not too tightly lodged, it may be loosened by prying the butt off the ground or by pulling it with equipment. Perhaps the most dangerous practice of all is to cut the tree in which the first one is lodged. If this is done it is difficult to judge the stresses involved, or the direction the two trees will fall. If this situation exists, cutting the standing tree with explosives is the safest procedure. Additional hand felling techniques and precautions are found in TM 5-342.

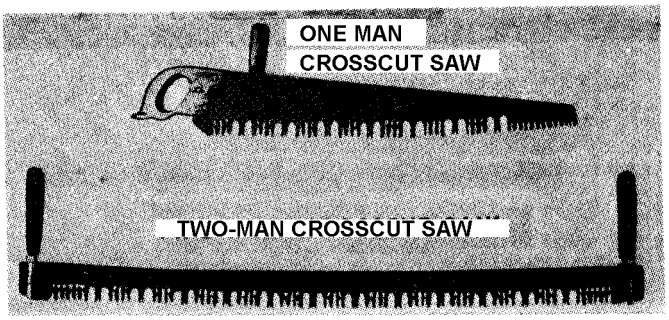


Figure 3-13. Types of saws.



Figure 3-14. Cutting hardwood tree with chain saw.

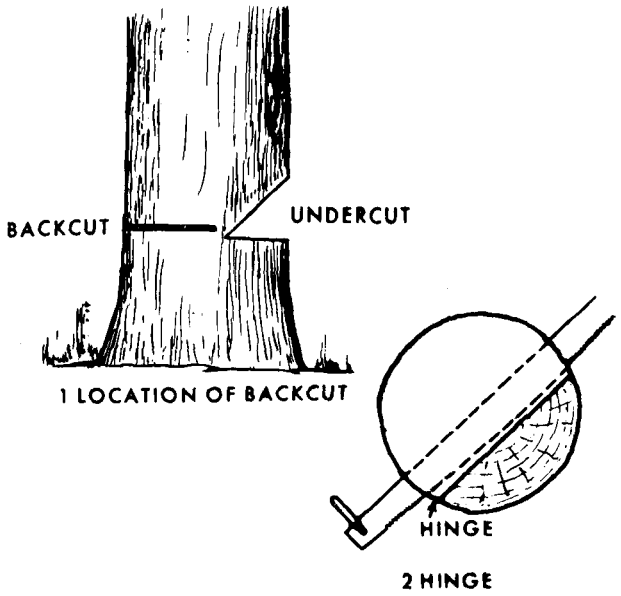


Figure 3-15. How to make the backcut and hinge.

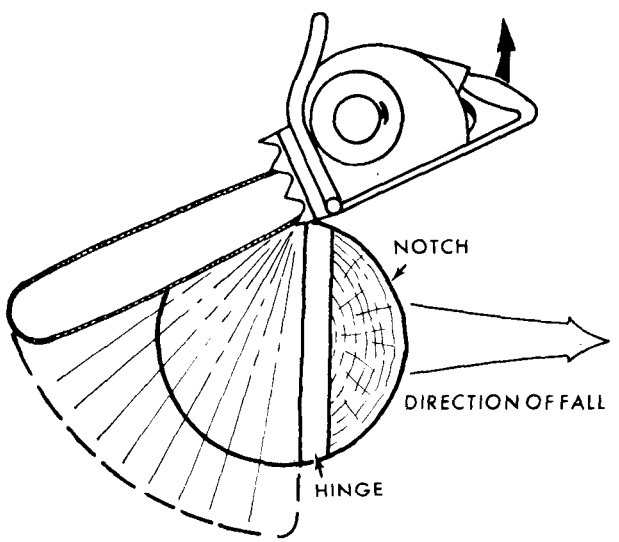


Figure 3-16. Normal felling cut.

c. Tractor or Wheel-Mounted Circular and Chain Saws. Greater production in larger diameter vegetation can be obtained using large horizontally mounted circular or chain saws. These saws are generally powered by a small four-stroke gasoline engine or the power takeoff of a small wheeled tractor. Trees up to 1.25 meters (50 inches) in diameter can be felled using the circular saw, while the chain saw is capable of felling trees 1.8m (72 inches) in diameter. Their use is not recommended on steep slopes.

d. Sickle Mowers. Light brush, with a stem diameter of less than 3.8 centimeters (1.5 inches), can be cut with agricultural tractor mowers adapted for heavy-duty operation. These mowers have short, heavier sickle bars equipped with stub guards and extra holddown clips. The tractor is run in low gear to give a high sickle speed in comparison with the forward speed. This equipment is usually most economical in intermediate sized, level areas of light and secondary growth.

e. Shearing Blades. Perhaps the most efficient land clearing tool for medium and large vegetation in intermediate to large sized areas is a shearing blade mounted on a track-type tractor. The shearing blade provides a sharp cutting edge. It is usually equipped with a stinger or wedge-like projection which may cause trees to be spilt in one or more successive passes before they can be felled with the cutting edge. Larger trees can be felled by the shearing blade mounted on a tractor. Shearing blades have an advantage over bulldozer blades in that they are easier to operate. Shearing blades are equipped with a flat soleplate mounted horizontally on the bottom of the blade which allows the blade to float on top of the ground without digging in. This permits faster operation with less operator fatigue, since the operator does not have to constantly manipulate the controls to keep the blade at ground level. Through the technique of shearing the vegetation at ground level and splitting the trees, disposal of the vegetation by burning is much faster and more complete, because the tree has been split and there is no rootball of soil on the butt of the logs. Vegetation is most easily sheared at or slightly below ground level since the shearing blade cuts the tree at its most firmly fixed point. On most species of trees this cut also occurs at or below the crown, the point where the root structure starts to form. The root wood fibers are not as strong as the stem, thus the tree shears easily at this point. There are two basic types of shearing blades, the angle blade and the V type blade. The angle-type blade in use by the military is the Rome K/G blade (fig 3- 17). This blade has an angle of 30 degrees, has the sharp projecting "stinger" mounted on the leading left side, and can be operated either by cable or hydraulically. The Rome K/G blade is available to fit most sizes of track-type tractors. The replaceable cutting edges and "stinger" should be resharpened with a portable grinder daily. More discussion of blade maintenance procedures is found in appendix D. A guide bar mounted on top of the blade is used to help control the direction the trees fall. The cut growth will normally fall forward and to the right of the operator. This type of blade is a versatile attachment which can cut, pile, and stump. It can be used on any terrain on which bulldozers can operate, and given enough time utilizing the stinger to split the tree it can fell any size tree (fig 3-18). The V blade (fig 3-19)

is also available for all track-type tractors. It is equipped with a heavy-duty "splitter," mounted in the center, angled, serrated cutting blades, and brush rack. The V is in two sections which bolt together so it can be disassembled for easier transport. The V blade has the disadvantage in dense growth that the trees fall to both the left and right of the tractor, thus felling trees into uncut forest. It is a high production land clearing tool which is very effective in sparse to medium density growth or for cutting trails one blade-width wide in dense growth. Unlike the angle blade, the V blade cannot pile or ditch. It extends forward further and is heavier so the center of gravity of the tractor-blade combination is moved forward. This makes it more difficult to operate when working on steep slopes and in soft underfoot conditions. The use of shearing blades of either type should be limited to heavier type clay and loam soils, relatively free of rocks and stones which can cause severe damage to the cutting edge. Under extremely sandy conditions a rake or other tool is more efficient than the shearing blades because the vegetation is readily uprooted and is not fixed firmly enough in the soil to be cut by a shearing blade.

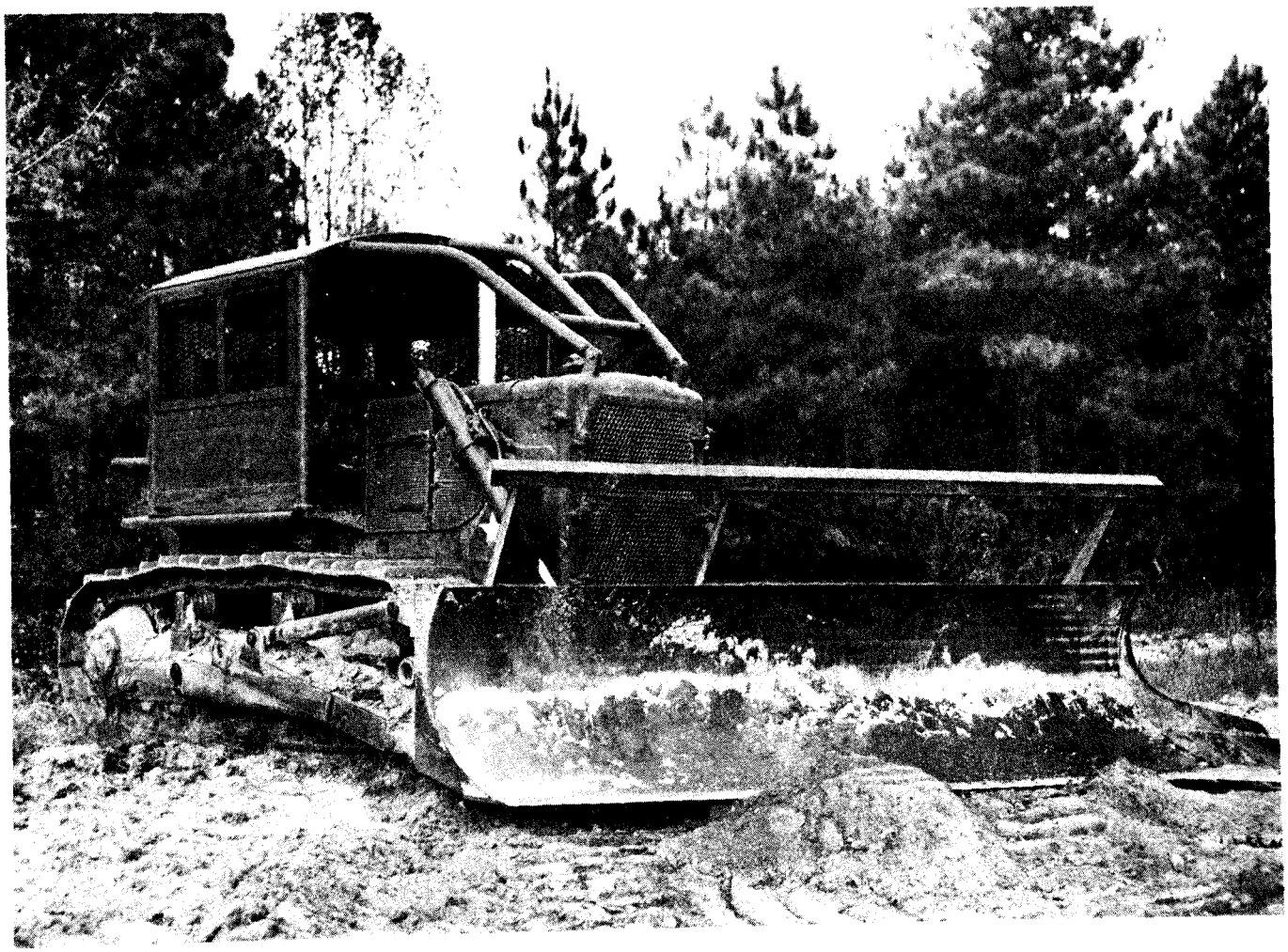


Figure 3-17. Rome K/G clearing blade.



Figure 3-18. Stinger on Rome K/G blade splitting the tree prior to felling.

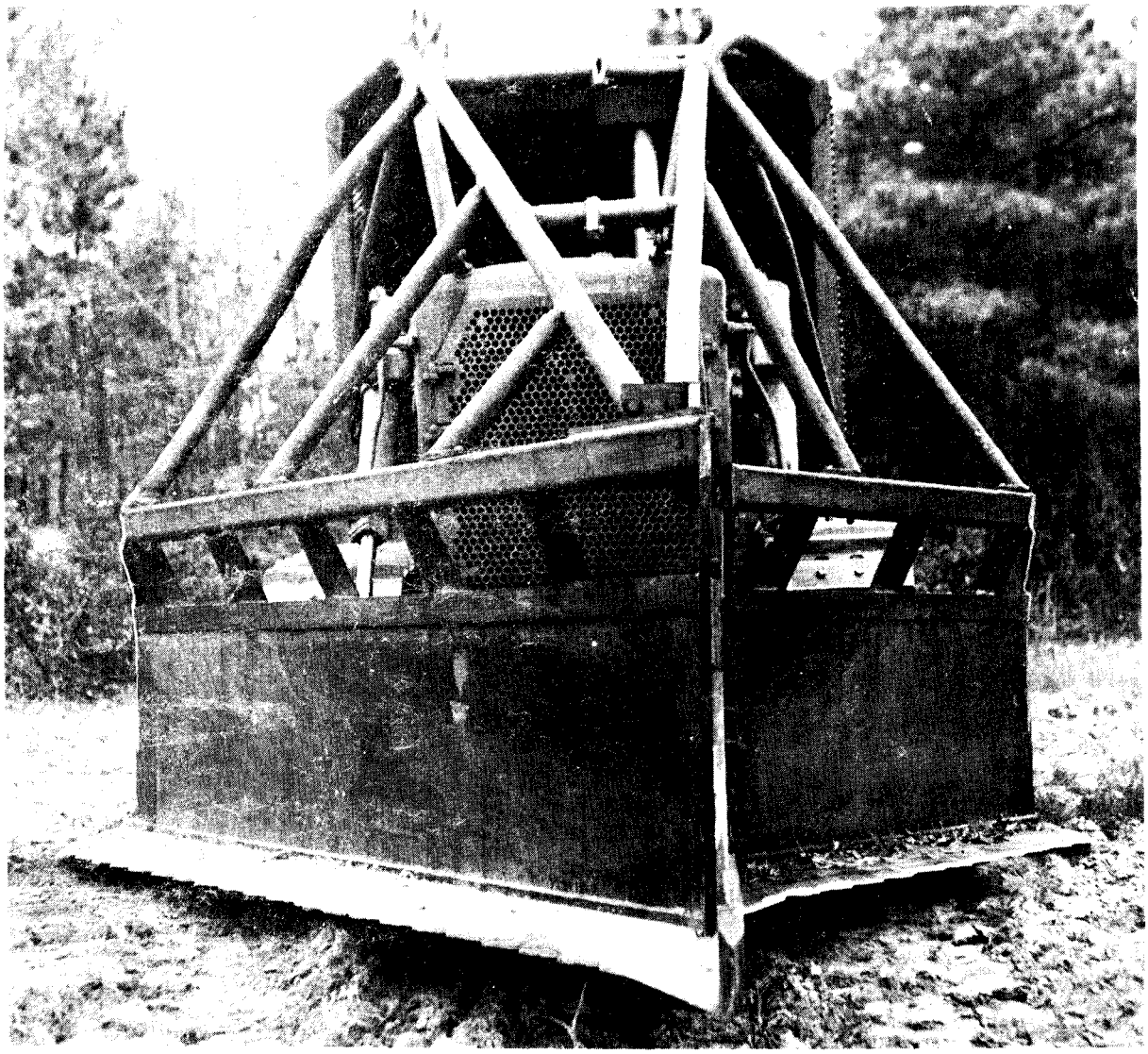


Figure 3-19. "V" type clearing blade with serrated cut edges and a center-mounted splitter.

3-10. Tree Clearing With Explosives

Trees may be cut with explosive charges. Information on explosives, determination of charge size, and methods of placing charges is contained in FM 5-25. Tree clearing operations are generally influenced by the time available, the equipment and explosives available, and the size and type of trees involved. Explosives application technique is determined by the diameter of the main stem trunk, the altitude of the tree (if directional felling is a consideration), and the root habit. Initial sizing of the explosive charge is determined by formula (table 3-1) and based solely on tree diameter; actual on-site experience will allow these initial values to be modified. Large-diameter trees may be cut with either external or internal charges. Externally applied charges may be placed rapidly and easily; internally applied charges require less explosive but require the use of drilling equipment and considerably more time and skill to prepare.

a. External Charges. The use of conveniently packaged block explosives such as TNT, tetrytol, composition C4, and dynamite is popular due to their ease of handling and simplicity of operation. These are fastened to the tree trunk at the desired point of cut. A formula based on the effectiveness of the particular explosive used in relation to that of TNT (table 3-2) may be used to provide charge size.

Table 3-1. Tree Felling; Basic Charge-Size Formulas

Method	Complete felling	Directional (partial) felling
EXTERNAL CHARGE		
Conventional (block explosive) [a]	$P_{(TNT)} = D^2/40$ [b] $P_{(C4)} = D^2/53.6$ [b]	$P_{(TNT)} = D^2/50$ [b] $P_{(C4)} = D^2/67$ [b]
Paste Explosive		
Ring Charge[c]	$P = D^2/90 + 1$	Nondirectional
Concentrated Charge	$P = (19/1000)\ D^2$	$P = (15/1000)\ D^2$
Shaped Charge	Results are variable; approximately 74 percent of conventional charge.	
INTERNAL CHARGE	$P_{(\text{any explosive})} = \frac{D^2}{250}$	Nondirectional

Note. P—Pounds of explosive D—Diameter of trunk, in inches

[a] Block explosives used in conventional method are usually TNT, dynamite, tetrytol, C3 or C4. The constant for TNT(40) is varied by applying the relative effectiveness factor, given in table 3-1, for other explosives.

[b] Reliable for trunk diameters $\leq$18"

[c] Reliable for trunk diameters $\leq$ 30"

[d] For example: An 18-inch-dia tree is to be felled with tetrytol applied externally.

From this table, we find the appropriate formula $P = D^2 / 40$, where P = pounds of TNT and D = tree diameter in inches. Therefore, $P = (18)^2 / 40 = 324 / 40 = 8.1$ lb of TNT. Since the relative effectiveness of tetrytol (from table 3-2) is 1.20, we require only 8.1 / 1.2 6.75 lb of tetrytol. Since tetrytol only comes in 2½-lb blocks (table 3-2), use 3 x 2½ = 7½ lb.

Table 3-2. Explosive Characteristics

Name	Principal use	Required for detonation	Relative effectiveness as external charge	Detonation fps	Cratering charge	Poisonous fumes	Water resistance	Packaging
TNT	Main charge, booster charge; cutting and breaching charge, general and military use in forward areas	Special blasting cap, electric or non-electric	1.00	23,000	Good	Dangerous	Excellent	1 lb, 50 or 56 to box
Tetrytol, M1, M2			1.20	23,000	Fair	Dangerous	Excellent	16 2½-lb blocks in wooden box
Composition C3 M3, M5			1.34	25,000	Excellent	Dangerous	Good	16 2¼-lb blocks in wooden box
M5A1 Composition C4 M112			1.34	26,000	Excellent	Slight	Excellent	24½-lb. blocks in wooden box
Ammonium nitrate (cratering charge)	Cratering and ditching	Special blasting cap, electric or nonelectric	0.42	14,800	Excellent	Dangerous	Poor	40-lb charge in metal can
Sheet explosive M186, M118 charge demolition	(See C-4)	(See C-4)	1.14	24,000	Poor	Slight	Excellent	80½-lb sheets/box 25-lb roll
Military dynamite M1	Quarrying stumping-ditching	(See C-4)	0.92	20,000	Good	Dangerous	Good	½-lb 100 to box

Name	Principal use	Required for detonation	Relative effectiveness as external charge	Detonation fps	Cratering charge	Poisonous fumes	Water resistance	Packaging	
Straight dynamite (Commercial) 40%	Land clearing, cratering, quarrying, and general use in rear areas, such as ditching and stumping	No. 6 commercial cap, electric or nonelectric	0.65	15,000	Good	Dangerous	Poor	102	Sticks per 50 lb box
50%			0.79	18,000			Good	103	
60%			0.83	19,000			Excellent	106	
Ammonia dynamite (Commercial) 40%			0.41	8,900	Excellent	Dangerous	Good	110	Sticks per 50 lb box
50%			0.46	11,000			Good	110	
60%			0.53	12,700			Good	110	
Gelatin dynamite 40%			0.42	8,000	Good	Slight	Good	130	Sticks per 50 lb box
50%			0.47	9,000	Good		Very good	120	
60%			0.76	16,000	Good		Very good	110	
PETN	Detonating cord	Special blasting cap, electric or nonelectric	1.66	20,000 24,000	NA	Slight	Good		
	Blasting cap	NA							
Tetryl	Booster charge	Special blasting cap, electric or nonelectric	1.25	23,400	NA	Dangerous	Excellent		
Composition B	Bangalore torpedo	Special blasting cap, electric or nonelectric	1.35	25,000	Good	Dangerous	Excellent	Bulk	
Amatol 80/20	--do--		1.17	16,000	Excellent	Dangerous	Poor		
Black Powder	Time blasting fuze	NA	0.55	1310 Max. Depends on Confinement	Fair	Dangerous	Poor	Bulk	
Nitrostarch	Substitute for TNT	Special blasting cap, electric or nonelectric	0.80	15,000	Good	Dangerous	Satisfactory	1-lb blocks	

(1) Direction of fall is dependent upon placement of the charges. Unless influenced by initial attitude or a strong wind, the tree will fall toward the side on which the charge is placed. The use of a small "kicker" charge of approximately 1 pound will provide a positive fall in the proper direction. Such a charge is placed about two thirds of the way from the ground to the top of the tree and on the opposite side of the main charge and desired direction of fall, as shown in figure 3-20.

(2) Though appropriate Army manuals do not place a limitation on tree size for the prior formula techniques, reliability decreases markedly for trees over 18 inches in diameter. Large trees may often be handled more easily by cutting a notch (using a chain saw or axe) and then placing block or plastic explosive within the notch. Tamping with sandbags, mud, or other material is also a good practice and will increase the effectiveness of any explosive charge.

(3) The characteristics of paste explosive, a semifluid, extremely oily explosive, with a consistency of light grease, permits the ready application of the explosive around a tree trunk such as the "ring charge" configuration. The highly plastic properties of the material insure its emplacement in close contact with the often irregular surfaces of tree trunks. This close placement may be achieved by hand molding. Adequate configuration and tapering of the upper and lower edges improves the efficiency

of the explosion. Ring charges are effective for completely severing trees up to 30 inches in diameter (a), (fig 3-21).

(4) Directional control by paste explosive may be best achieved with concentrated rectangular charges applied to the trunk as in (b), figure 3-21. Table 3-1 provides formulas for an estimate of paste explosive quantities required.

(5) Shaped charges may be utilized and are more efficient than conventional block explosives. Shaped charges may be field improvised by loading coffee cans or other containers with C4 and forming it around a conical or wedge-shaped (linear) mold in one end. Fusing and detonation are from the rear. They have about the same effectiveness as paste explosives.

b. Internal Charges. Trees may be felled with less explosive by use of internal charges placed in boreholes. If necessary, calculation of the explosive quantity required may be made by use of the related formula (table 3-1); any common explosive may be used since the relative effectiveness factor is not significant. The charge is placed in a borehole drilled parallel to the greatest cross-sectional dimensions of the trunk and tightly tamped with moist soil; if the trunk is nearly circular, two nonintersecting holes may be drilled at right angles to each other, tamped, and fired simultaneously as illustrated in figure 3-22. Priming and detonation are conventional.

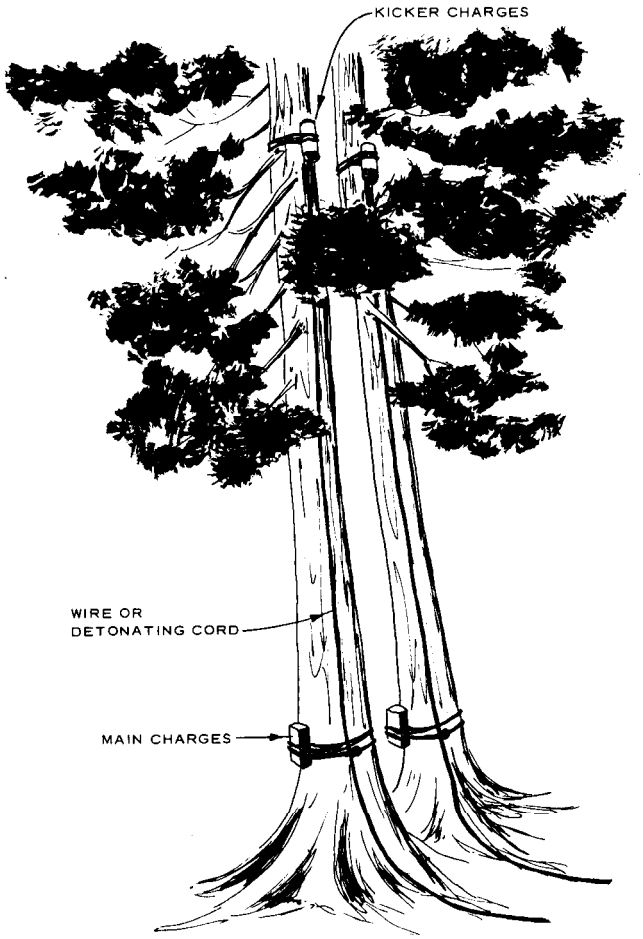


Figure 3-20. Use of kicker charge for controlling direction of fall.

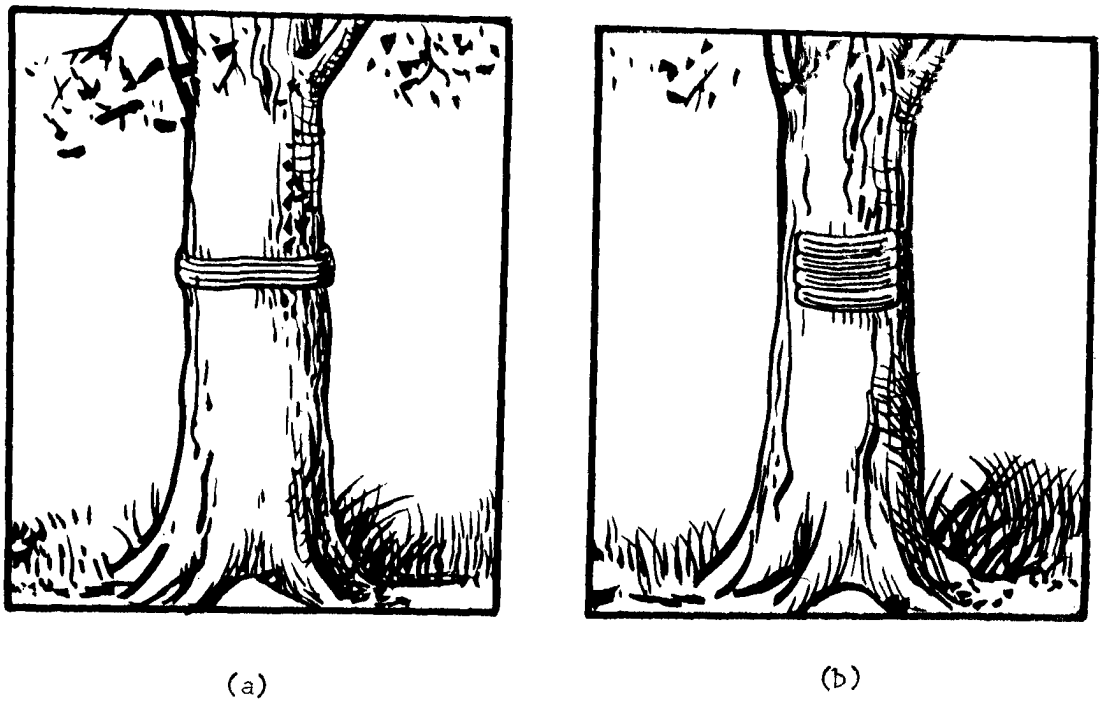


Figure 3-21. Paste explosive. (a) Ring charge (b) Rectangular charge.

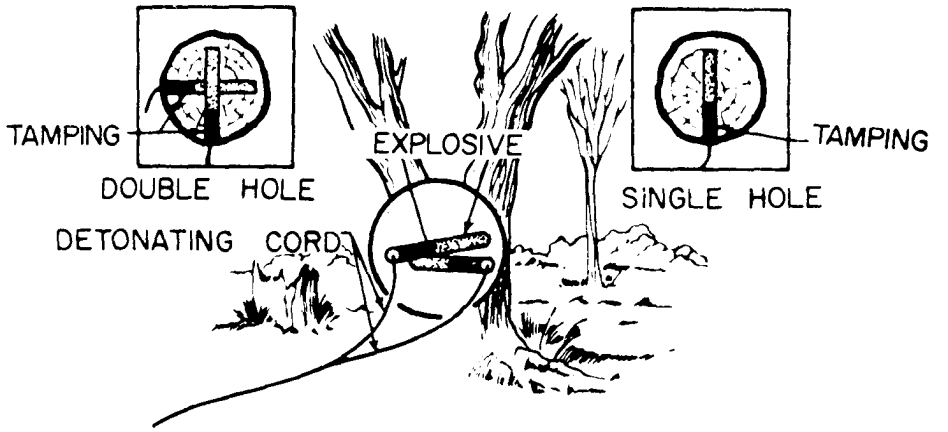


Figure 3-22. Placement of internal timber-cutting charges.

3-11. Leveling Scrub Growth and Light Vegetation

Mowing equipment, rolling choppers, and tractor-drawn anchor chains are an extremely fast and effective means of clearing and leveling scrub growth and other light vegetation. In primary rain forest areas, this technique is limited to secondary growth and underbrush while larger vegetation must be removed by another means. Since most of the vegetation is not uprooted and is often chopped up, it is normally not piled for disposal, but may be burned in place after drying is completed or left in place to decay.

a. Rotary Mowers. Heavy duty rotary mowers pulled by tractors can be used for vegetation up to 10 centimeters (4 inches) in diameter (fig 3-23). They have one or more revolving blades, rotating around a vertical shaft and powered by the tractor power takeoff, which sever the vegetation at or near ground level and shred it into small pieces. Rotary mowers should not be used on steep slopes or where rocks and stones are present.

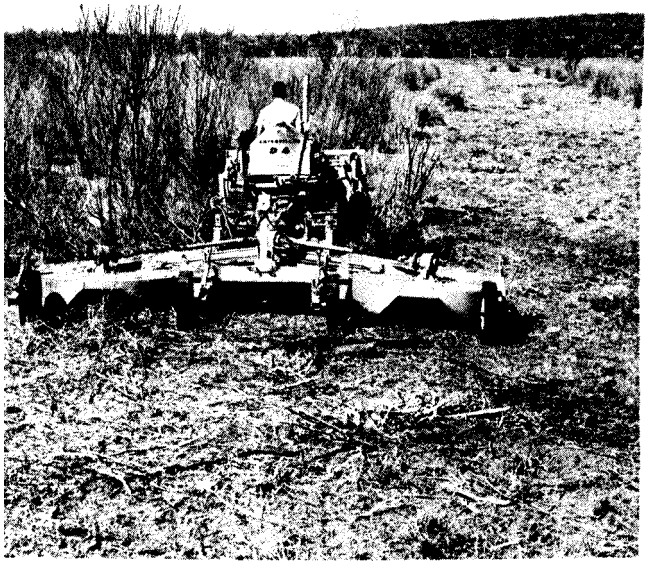


Figure 3-23. Three blade wide rotary mower.

b. FlaIl-Type Rotary Cutters. Flail-type rotary cutters are also drawn by a tractor and have cutting knives or chains which rotate around a horizontal shaft to knock down or shred small brush at or near ground level. These cutters are available in a wide range of sizes and widths as power takeoff attachments for both wheeled and track-type tractors. Their application is limited to small and medium sized brush in intermediate size areas.

c. Rolling Choppers. In larger sizes of small to medium diameter brush and secondary growth, the fastest method of clearing is with a rolling chopper (fig 3-24). The rolling chopper is a drum with cutting blades. Cutting blades are attached by welding or bolting to the drum, which may be filled with water to increase its weight. These blades are 15 to 25cm (6 to 10 inches) wide and cut, fracture, and shatter the vegetation. The effectiveness of the cutting action is determined by the firmness of the soil, the weight of the drum, and the speed at which the drum is rolled. Increasing the speed at which the drum is rolled improves its effectiveness so that towed choppers should be pulled in second or third gear. Rolling choppers are manufactured in several widths and weights per length of cut. They also may be connected in dual, tandem, and triple arrangements in addition to the single drum. A unique rolling chopper (fig 3-25), called the Marden Duplex, has two drums connected with a draglink on one side of the frame so the drums are towed at a 20 to 30 degree angle to each other and to the forward direction of the tractor. This angle produces a dragging and rolling reaction on the drums and prevents the rear drum from following the same cut pattern as the front drum. The Marden cutter also uses a “hi-lo - blade” concept by alternately mounting 6- and 8-inch width blades to produce greater chopping impact on the vegetation. Rolling choppers do not cut grass or other light vegetation, thus allowing the spread of native grasses which prevent soil erosion or dust problems in areas cleared by this method. The main disadvantage of rolling choppers is that they are limited in use to vegetation of 6 to 8 inches in diameter and smaller.

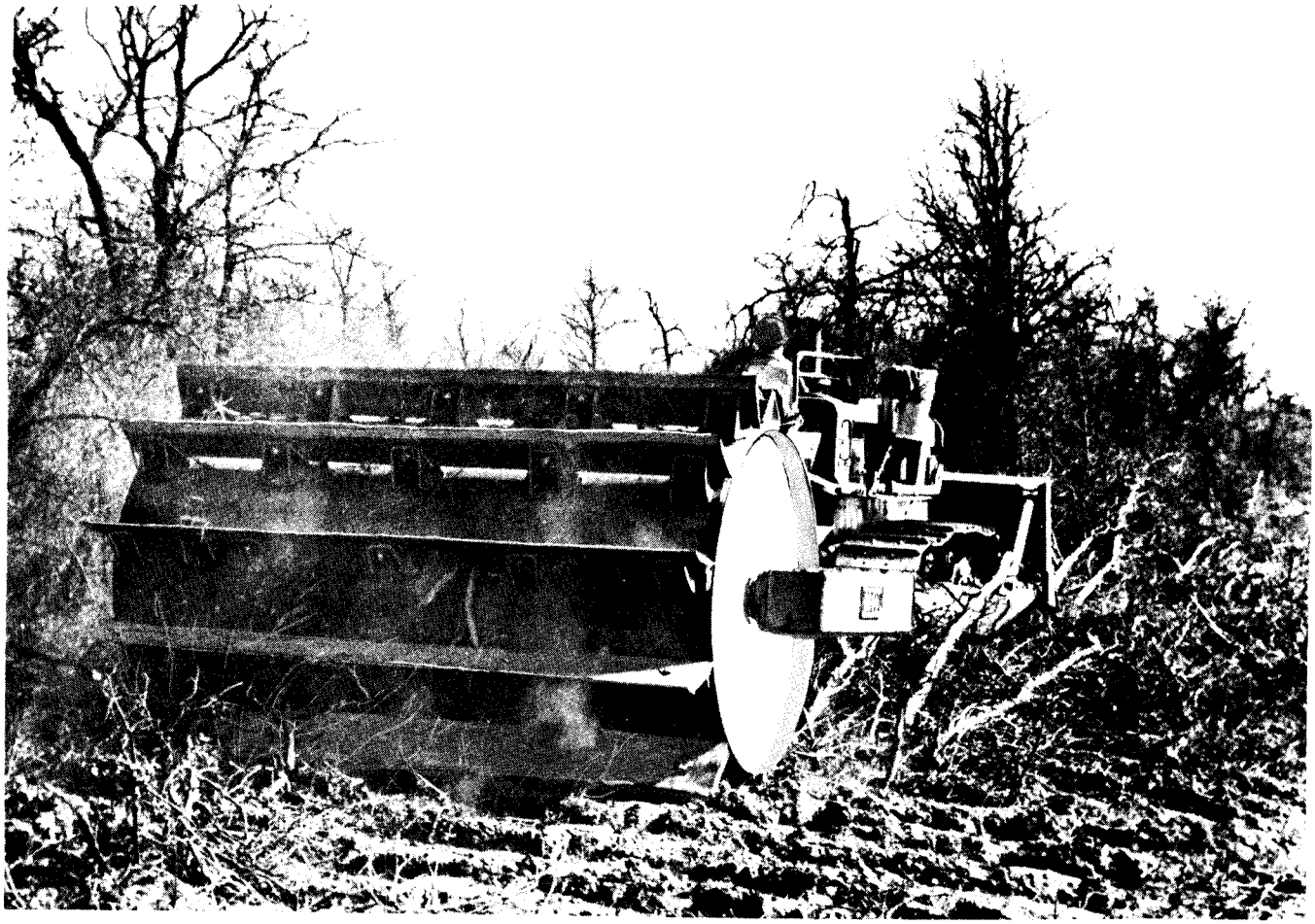


Figure 3-24. Single drum rolling chopper.

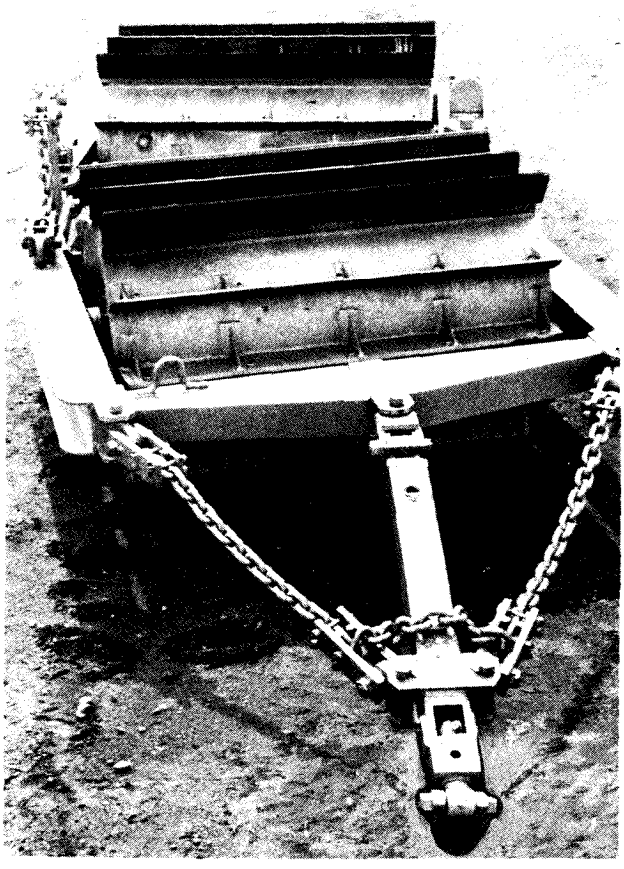


Figure 3-25. Dual drum offset Marden Duplex rolling chopper.

d. Anchor Chains and Large Crawler Tractors. In small vegetation the use of anchor chains and large crawler tractors can be the most efficient method available for knocking vegetation to the ground. In larger vegetation, the growth is uprooted rather than bent over and knocked down. The equipment and techniques are the same as those described in paragraph 3-8.

3-12. Tilling Vegation Into the Soil

Many thousands of acres can be cleared every year simply by the use of agricultural tillage implements pulled behind a tractor. These implements act to cut and chop the vegation into the upper 15 to 25 centimeters (6 to 10 inches) of the soil. This method is limited to vegation that does not exceed 7.5 to 10 centimeters (3 to 4 inches) in diameter. To use this technique, the soil surface should be free of large stumps protruding above the ground, large tree stems lying on the surface, and stones or stone outcrops which may damage or otherwise limit the effectiveness of the implement in chopping the woody vegation.

a. Moldboard Plows. Pull-type, semimounted, or fully mounted moldboard plows drawn by wheel or track-type tractors can be used to turn over and, cover small brush if the soil is not excessively hard, sticky, or rocky. For all but the lightest plowing, plows with heavy duty frames must be used. Plows are available in a wide range of sizes from many farm equipment manufacturers. Moldboard plowing of an area requires considerable effort and should be done only in those areas where long-term totally cleared conditions are required. Moldboard plows are norm ally used only for agricultural clearing purposes.

b. Disk Plows. Tractor-drawn disk plows can also be used effectively in covering small brush. They can be used on soil that is dry, hard, sticky, or rocky where moldboard plows are unable to work. Disk plowing does not normally cover the brush as thoroughly as moldboard plows. Variations of the standard disk plow have been developed which incorporate a “stump jump action”, where each disk is independently spring-loaded to permit it to ride over fixed obstructions which may be encountered. Disk plows should be used only where complete long-term clearing is required. Dust and erosion control procedures must be instituted in areas cleared with disk plows.

c. Offset and Gang Disk Harrows. For slightly larger brush and secondary growth up to 4 inches, heavy-duty offset and gang harrows, pulled by track-type tractors equipped with bulldozer blades or clearing rakes, are effective clearing tools (fig 3-26). The vegetation is bent over by the blade or rake and then is cut and chopped into the topsoil by the harrow. Offset and gang harrows do not invert the soil layer or the vegetative matter, but will chop up the material and mix it with the soil. Large sound stumps and fallen trees inhibit the use of harrows and even heavy-duty harrows may be damaged if care is not taken to avoid these obstacles. Harrows are extremely useful in clearing secondary growth in areas which have been previously cleared, if the tree stems have decayed or have been removed and the stumps were cut flush with the ground. Use of a harrow to clear growth requires more effort than use of a rolling chopper but the vegetative regrowth is retarded for a longer time. The disadvantages of the harrow are the limited size vegetation that it can cut and the fact that the soil must be firm or the harrow will bog down. The soil in the area cleared by a harrow is disturbed so that it can become a dust or erosion problem if preventive measures are not taken. Areas cleared by a harrow are normally immediately ready for agricultural planting.

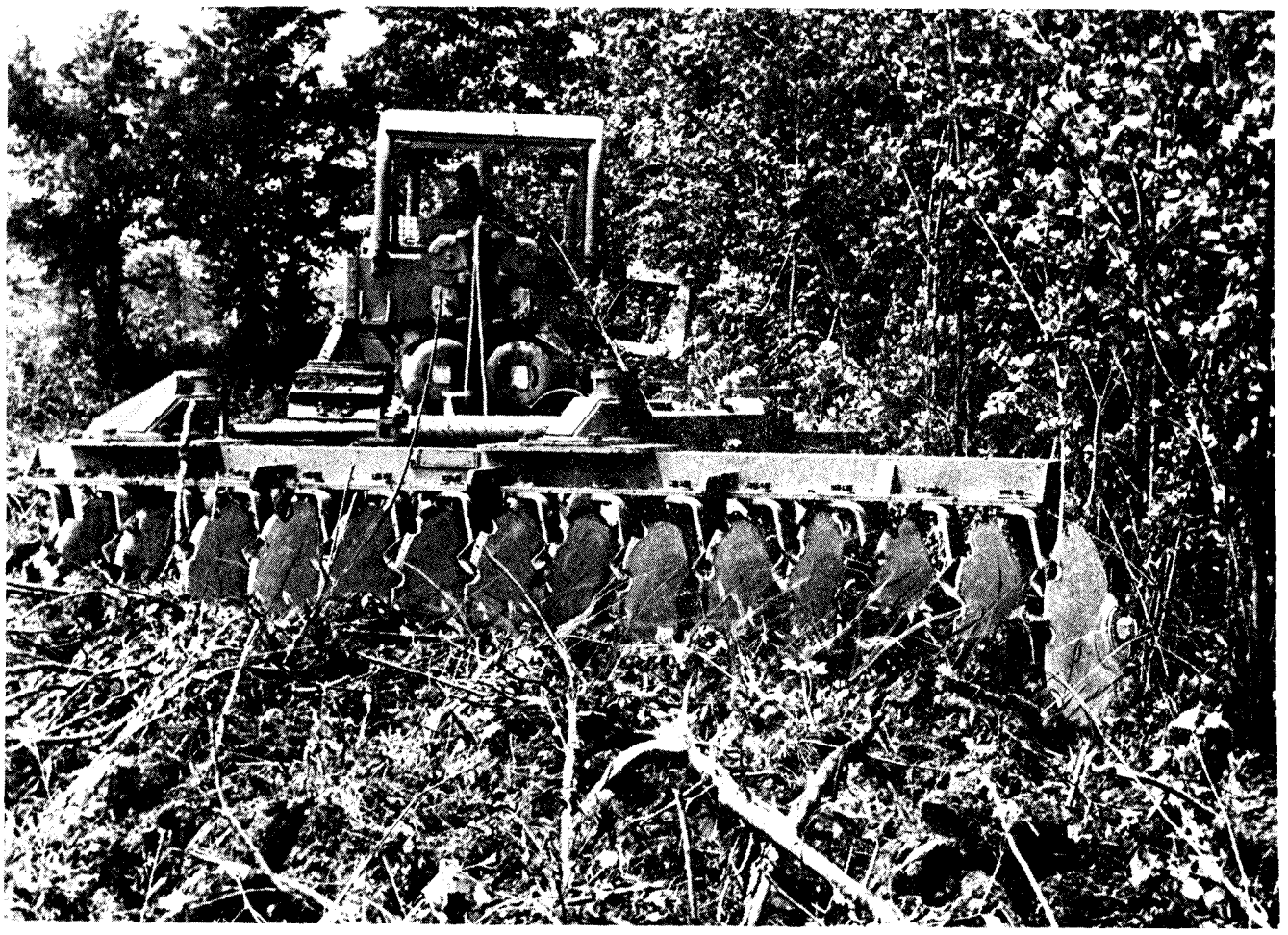


Figure 3-26. Hinge-type offset harrow clearing 2-inch vegetation.

3-13. Burning

Burning can be used as an initial clearing method, but it is very difficult to get a complete burn or control it in most types of vegetation without extensive preparation. If herbicides are permitted to be used prior to initiating the burn, more complete results can be obtained. National policy will govern the use of herbicides in a theater of operations. Commanders will receive specific guidance for their use together with the necessary authority to employ herbicides through command channels. Many tropical jungles are impossible to burn even with extensive defoliation. Burning can be used effectively in many areas as a method for disposal of vegetation previously cut, knocked down, or uprooted, which has been left in place or windrowed. Further discussion of burning as a method of disposal is included in paragraphs 3-21 through 3-26.

3-14. Combinations of Felling Equipment

On many land clearing jobs more than one type of equipment may be used in combination to achieve the fastest and most efficient results. A common combination in many military operations is the power chainsaw, explosives, and the shearing blade. Extremely large vegetation, over 36 inches, and that which is located on extremely steep slopes, over 25 percent, often cannot efficiently be felled with a shearing blade. Therefore, it is often more economical to cut this vegetation by hand using explosives or power chainsaws. The combination of the knockdown beam and the anchor chain can be used in large vegetation, or in rocky areas where the chain may become snagged on a very large tree or a rocky outcrop. The knockdown beam following behind the chain can assist in knocking down the large tree or lift the chain over the rocks. On extremely steep slopes, two track-type tractors equipped with bulldozer or shearing blades can be connected back to back with a cable and winch to prevent them from overturning as they clear steep hillsides using the "yo-yo" technique: One tractor remains on top of the slope for stability as the other moves down the slope clearing the vegetation as it goes. In areas where several different types of vegetation occur, various combinations may be used to efficiently clear the area. A summary of methods and equipment used for initial felling listed by size of vegetation and size of area is included in the tables 3-3, 3-4, and 3-5. The most economical size area for each type of equipment will vary with the availability of the equipment or hand labor. When no equipment is listed in the tables for a certain size area using a particular method, it is normally not economical to use that method. However, heavy equipment listed under large areas can be used for smaller areas with less economical results.

Table 3-3. Light Clearing (Vegetation up to 5cm (2 in) Diameter)

Size area	Method: Uprooting vegetation	Method: Cutting or shearing vegetation at or above ground level	Method: Leveling scrub growth and light vegetation	Method: Tilling vegetation into the soil
		Equipment		
Small areas 4.0 hectares (10 acres).	Grub hoes and mattocks.	Axes, machetes, brush hooks, grub hoes and mattocks, wheel-mounted circular saws.		
Medium areas 40 hectares (100 acres).		Heavy-duty sickle mowers (up to 3.7 cm—1½" - diameter), tractor-mounted circular saws.	Rotary mowers, flail-type rotary cutters; rolling chopper.	Moldboard plows, disk plows, disk harrows.
Large areas 400 hectares (1,000 acres).	Blade rake, grubber, root plow, anchor chains.		Rolling chopper, flail-type cutter, anchor chains.	Moldboard plows, disk plows, disk harrows.

Table 3-4. Intermediate Clearing (Vegetation 5 to 20cm (2 - 8 in) Diameter)

Size area	Method: Uprooting vegetation	Method: Cutting or shearing vegetation at or above ground level	Method: Leveling scrub growth and light vegetation	Method: Tilling vegetation into the soil
		Equipment		
Small areas 4.0 hectares (10 acres).		Axes, explosives, crosscut saws, power chain saws, wheel-mounted circular saws, and chain saws.		
Medium areas 40 hectares (100 acres).		Power chain saws, tractor-mounted circular and chain saws.	Rolling chopper (up to 12cm (5") dia) rotary mower (up to 10cm (4") dia).	
Large areas 400 hectares (1,000 acres).	Shearing blade angling (tilted), bulldozer blade, rakes, anchor chain, root plow, spade plow.	Shearing blade (angling or V-type).	Flail-type rotary cutter, anchor chain.	Bulldozer blade or rake with heavy-duty harrow.

Table 3-5. Large Clearing (Vegetation 20cm (8 in) Diameter or Larger)

Size area	Method: Uprooting vegetation	Method: Cutting or shearing vegetation at or above ground level	Method: Tilling vegetation into the soil
		Equipment	
Small areas 4.0 hectares (10 acres).		Axes, explosives, crosscut saws, power chain saws.	
Medium areas 40 hectares (100 acres).	Shearing blade angling (tilted). knockdown beam, rakes, spade plow.	Shearing blade (angling or V-type), shearing blade—power saw combination, tractor—mounted circular and chain saws.	
Large areas 400 hectares (1,000 acres).	Shearing blade angling (tilted), knockdown beam, rakes, anchor chain,	Shearing blade (angling or V-type), shearing blade—power saw combination.	Anchor chain.

Section III. REMOVAL OF SUBSURFACE VEGETATION AND STUMPS

3-15. Factors to Consider

Many specifications require that a minimum of subsurface growth and stumps are to be left after clearing. When clearing equipment or logging operations sever the vegetation at or near ground level, a second operation to remove this subsurface material is necessary. If it is known that the stumps and roots must be removed prior to starting the project, serious consideration should be given to uprooting the vegetation as the initial felling technique. By uprooting the trees initially, the added leverage of the height and weight of the tree will assist in removing the roots, and thus will require less effort than removing the stump separately as a second operation.

3-16. Cutting Blade

The Rome K/G blade cart be used to grub the stump either after cutting the tree at ground level or without first cutting down the tree. After tilting the blade forward, the initial pass is made just to the right of the tree or stump severing the roots 1 to 2 feet below ground level (fig 3-27). The second pass is made with the stinger to the left of the tree or stump,

severing additional roots and uprooting it. This method does not remove all the subsurface growth, but in most cases only roots 1 inch in diameter and smaller remain in the soil. If the cutting blade is used in this manner, additional sharpening of the cutting edge and stinger will be necessary, especially in abrasive soils.



Figure 3-27. Rome K/G blade in a tilted position shearing a stump below ground level.

3-17. Stumpers

Both detachable and pull stumpers may be available as specialized items for stump removal. The detachable stumper is a one-piece casting which mounts to a track-type tractor C frame in place of the blade (fig 3-28). For larger or tougher stumps, a detachable splitter is available to use in conjunction with the stumper. This tool concentrates the power of the tractor directly on the stump and splits it, digging under it and lifting it out of the ground. The pull stumper is a cast steel tooth and frame which is connected to the rear of the tractor (fig 3-29). A rear cable control unit is required to raise and lower the stumper. One additional feature of the pull stumper is that it can be used to cut the side roots of large trees and stumps prior to their removal.



Figure 3-28. Detachable stumper with splitter.



3-18. Rooter

The rooter with one or more teeth removed can be used in a manner very similar to a pull stumper, but the shank penetration and lift is not as great as with the pull stumper.

3-19. Winches

Another method of stump or tree removal is to pull them by means of a winch and a chain or cable attached around the trunk. This line is normally a choker type which tightens its grip as the pull increases. This method of removal is preferred when the ground is too rough or soft to allow the tractor to get at the stumps directly, or more force is necessary than the traction will permit. Specially designed clearing units consisting of a small wheeled tractor equipped with a special winch that can develop a 100,000 pound line pull are used to pull over and uproot trees and stumps. Winches mounted on medium to heavy tractor-dozer units can develop a line pull of 51,000 to 74,000 pounds. The effective force on the stump or tree can be increased by installing one or more blocks to improve the mechanical advantage (fig 3-30). For detailed information on the methods of rigging see TM 5-725. This method can be used for trees and stumps up to 24 inches in diameter. Clearing done by pulling with winch units is extremely slow and requires skilled personnel to do the proper rigging. For most efficient results their use should be limited to those stumps and trees that cannot be removed through other means.

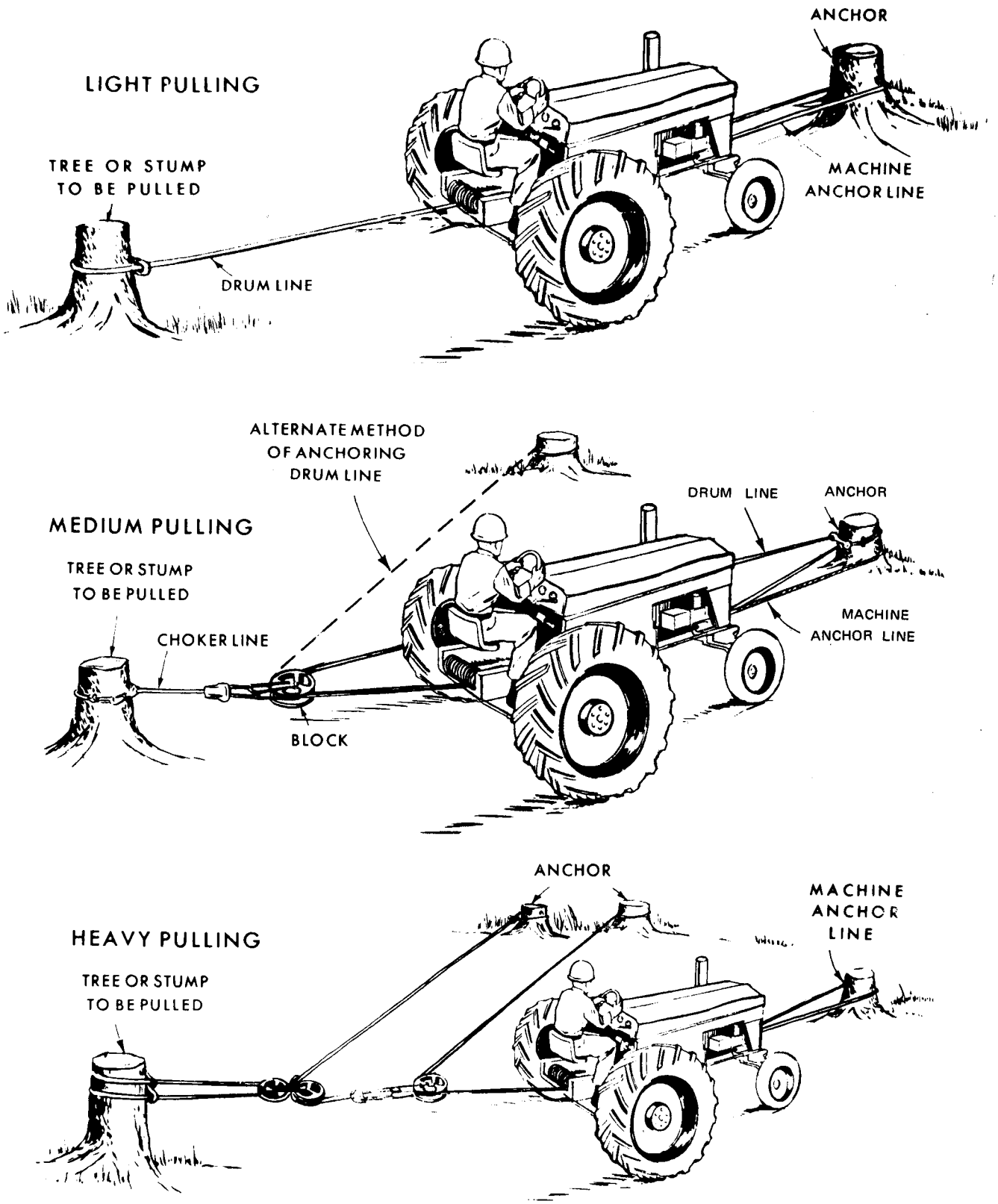


Figure 3-30. Clearing unit rigged for light, medium, and heavy pulling.

3-20. Removal of Stumps With Explosives

Tree stump removal by explosives may be necessary in the course of initial helicopter landing zone construction, expansion and improvements of such sites, and during the course of construction of field fortifications and artillery positions.

a. The type and condition of root system and the nature of the soil affect the placement, size, and effectiveness of explosive charges. While most trees have lateral roots lying near the surface, some species also have one or more main taproots extending downward. An old dead stump in a moist heavy clay or loam soil normally requires less explosive than a new "green" stump in dry loose soils with a high sand content. Dynamite is the preferred explosive, but any conventional explosive may be used.

(1) A rule of thumb is to use one pound of dynamite per foot of stump diamter (as measured 12-18 in. above the ground) for dead stumps and twice this amount for live or green stumps. Table 3-8 indicates recommended charge sizes that have been found satisfactory under varying conditions, but it is advisable to plan for several trial shots.

(2) The proper placement of charges requires judgement and experience, particularly when removing lateral-rooted stumps. If a single charge is used, it should be placed under the center of resistance of the root system. Multiple charges would likewise be distributed in the most effective manner. The depth and size of the hole will vary with the size of the stump; holes may be dug with a driving bar and sledge or a soil auger.

(3) Taprooted stumps can best be blasted by drilling into the taproot with an auger at an angle of about 450 to a point just beyond the center of the mot. External placement of charges requires less effort but more explosives. In this case, one or more holes are dug 2 to 3 feet below the surface and adjacent to the root (fig 3-31). In all cases, the holes should allow sufficient room for at least 8 inches of stemming with packed soil. Particularly large stumps with a heavy root system may be blasted with a single charge by first "springing the borehole." This requires the use of about ½ pound of dynamite to be inserted in the hole to form a cavity large enough to contain the required explosives. When the soil has cooled sufficiently, the hole may be loaded, tamped, and fired.

b. Proper loading of a hole requires that the hole be checked, for obstructions prior to loading, the charges be tamped firmly together by use of a wooden tamping stick, and the hole be stemmed with firm, moist earth. If several charges are to be used in one hole and no water is present, the cartridge wrappers should be slipped open and pressed firmly together to insure effective detonation. The final cartridge, which is to be primed, is not slipped open except as necessary for priming. The charges may be primed and detonated by several conventional methods, but aboveground systems, such as the use of detonating cord to connect the subsurface dynamite to aboveground electric or nonelectric blasting caps, are preferred. If a time fuse and nonelectric blasting cap system is necessary, each charge should be dualprimed to insure detonation.

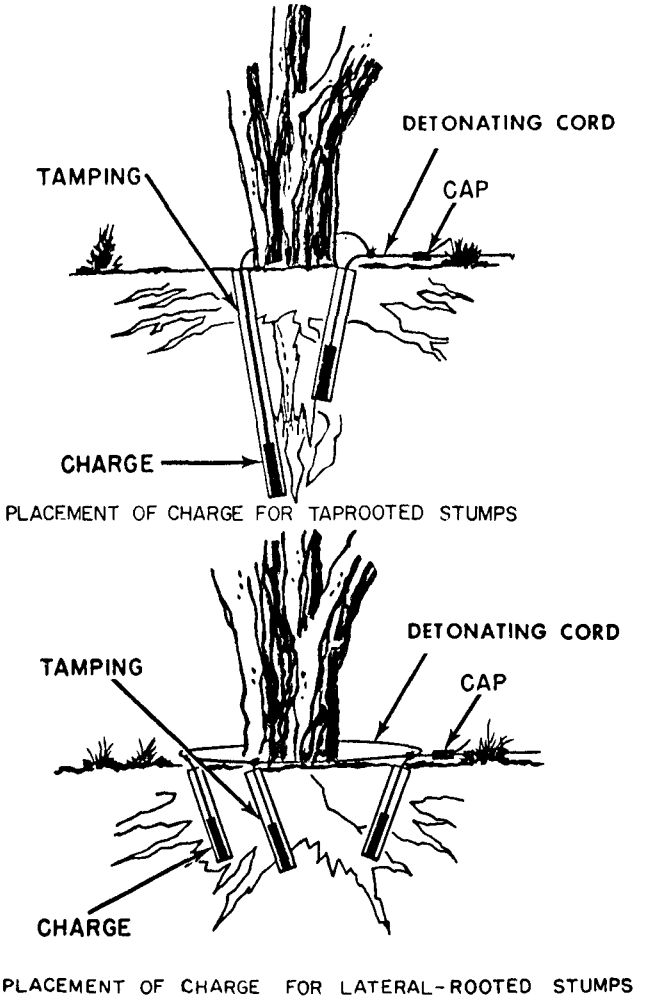


Figure 3-31. Stump blasting charges.

Table 3-6. Stump Blasting Charge Sizes Required Under Varying Conditions.

HARDWOOD STUMPS

Moist, firm soil

Diameter 1 ft above ground	Condition of stumps	Pounds of dynamite
6"	Green	1
	Old, Solid	¾
	Dead	½
12"	Green	2
	Old, Solid	1½
	Dead	1
18"	Green	2½-3½
	Old, Solid	2
	Dead	1½
24"	Green	3½-5
	Old, Solid	3
	Dead	2
30"	Green	5-6½
	Old, Solid	3½
	Dead	2½
36"	Green	6½
	Old, Solid	4½
	Dead	3
42"	Green	8
	Old, Solid	6
	Dead	4
48"	Green	10
	Old, Solid	7½
	Dead	5

TAPROOTED PINE STUMPS

Charge loaded in taproot moist soil

Diameter 1 ft above ground	Condition of stumps	Pounds of dynamite
6"	Green	1
	Dead	½
12"	Green	1½
	Dead	¾
18"	Green	2½
	Dead	1
24"	Green	3½
	Dead	1½
30"	Green	5½
	Dead	1¾
36"	Green	7
	Dead	2½

LATERAL-ROOTED WHITE PINE STUMPS

Old but solid moist soil

Diameter 1 ft above ground	Kind of soil	Pounds of dynamite
18"	Heavy	1-1½
	Light	1½-2
24"	Heavy	1½-2
	Light	2-3
30"	Heavy	2½-3
	Light	3-5
36"	Heavy	3½-4
	Light	5-7½
42"	Heavy	5-6
	Light	7½ up

Note. More explosives are required in dry soil than in wet soil.
When five or more cartridges (½ lb sticks) are used, springing is usually necessary.
Large green stumps are more easily shot with distributed charges.

Section IV. DISPOSAL OF DEBRIS

3-21. General

Once the vegetation has been felled, it must usually be disposed of in some manner. Since disposal of the vegetation is often as time-consuming as the initial felling, care should be taken to specify only that degree of disposal absolutely essential to accomplish the purpose of the clearing project. The method of disposal will be influenced by a number of variables, including type and size of vegetation, specifications, minfall, and terrain.

3-22. Left in Place

Small vegetation that is chopped up during initial clearing is normally left in place to decay, be burned, or be incorporated into the topsoil. When determining disposition to be made of larger vegetation, both the long and short term use of the land are important considerate ions. If clearing is for tactical purposes only, the large vegetation may be left in place; however, secondary growth may have to be cleared later, and the task will be extremely difficult if the large tree stems remain in place. If at all possible, the large vegetation should not be left in place and should be disposed of in some manner.

3-23. Burned in Place

Burning vegetation in place after it has been felled can be an effective means of disposal when conditions permit. These conditions include fuel for burning in the form of grasses, small limbs, or brush, and a dry enough climate to allow burning. A period of a few days to several weeks may be necessary for proper drying of the felled vegetation. Heavy jungle brush with many large trunks may take 1 ½ to 2 months or longer to dry sufficiently before burning. Complete burning of large diameter vegetation is normally not possible without adding additional fuel in the form of POL, dry grass, or brush. If time permits, an effective means has been the plant grass in the felled area, and to delay burning until the grass has grown and dried sufficiently to serve as a fuel. Chemical spraying of the vegetation with herbicides prior to felling will sometimes accelerate the drying process and insure that the small vegetation is dry before burning. In order to effectively control an in-place burn, it is necessary to establish fire lines or belts around the boundaries of the area to be burned. In rain forest areas, these belts are normally unfelled vegetation. In dry areas extreme caution should be used when burning, especially in heavy winds. Escape routes cut in the area are essential for the safety of the burners. To ignite the area, the burners should move through the area with kerosene soaked cloth strips which are thrown into the felled vegetation starting at the up slope or downwind side of the area and setting closely spaced fires along the line. In larger vegetation, it will be necessary to prune, stack, and reburn according to the clearing specifications, to accomplish complete disposal.

3-24. Piling

If vegetation is not disposed of in place, it is normally piled, then burned or left to decay. Light vegetation, including shrubs and tree branches, may be shredded with a shredding machine. Heavy vegetation (timber) may be piled with a grapple (fig 3-32). The equipment used for piling is often determined by what equipment was used for felling. The angled shearing blade and clearing rakes previously discussed are quite suitable for piling. In small areas of light vegetation, piling can be done by hand. If rain is not expected the cut vegetation should not be piled until it has dried, then it should be piled and burned immediately. If the clearing is done during a period of heavy rain, the vegetation should be piled immediately after felling and allowed to dry in the windrow.



Figure 3-32. Truck-mounted grapple.

a. Cutting Blades. One advantage of the angled shearing blade is its multiple application as both a felling and piling tool (fig 3-33). The "stinger" can be used to partially lift the vegetation, and the floating action of the blade on its sole plate permits the blade to carry the vegetation to the pile with very little dirt to produce a cleaner, better burning windrow.



Figure 3-33. Multiple tractor piling operation using angled cutting blades.

b. Clearing Rakes and the Spade Plow. These tools can also be used for both felling and piling. They are especially effective in removing surface roots while piling. Excess soil passes between the teeth of these tools and very little is carried to the windrow except in wet or cohesive soils which stick between the teeth causing unsatisfactory results.

3-25. Logging

Often the area to be cleared contains valuable trees which can be marketed as saw timber, pulpwood, firewood, or charcoal. If logging is to be done, it should be conducted before or after the clearing operation. The two jobs cannot be done efficiently together. Normally most trees sheared or uprooted are not suitable for saw timber because they are split as they are felled. Thus, if saw timber is desired, it must be removed prior to clearing. In many areas, most of the vegetation can be disposed of for pulpwood or firewood and often will be removed by lumber companies or indigenous personnel with no expenditure of effort by the clearing unit.

3-26. Removal of Debris

When swamps or low-lying areas are located in the area cleared, it is sometimes desirable to pile brush in these areas. The main problem with this method of disposal is that the natural drainage can be impeded. Vegetation is often piled in well-placed windrows and left to decay. In level areas the windrows may be parallel, but in hilly areas the windrows should be left on the contour to facilitate piling and to help control erosion. If the vegetation is to be burned in windrows, they must be piled as compactly as possible, parallel to the prevailing winds and with a minimum of soil mixed with the vegetation (fig 3-34). The vegetation should be allowed to dry until the bark on the larger tree cracks and the foliage has dried and begun to fall. If the vegetation is extremely difficult to burn, it may be necessary to aid the burning with forced air and fuel or a combination of both. Brush burners equipped with 4-cycle engines, airplane-type propellers, and self -priming pumps can be obtained (fig 3-35). They supply air at a high velocity with a continuous fuel spray for starting and maintaining fires. After the initial burn, repiling should start just as soon as the heat has subsided enough to permit a crawler tractor with a blower-type fan to approach the fire without damage. piles should be stoked and the fire kept alive until all the woody material is completely

consumed by the flames. Windrows should be cut into segments as soon as possible, making round piles of burning debris which will maintain the higher temperature necessary to consume the larger diameter material. The best tools for repiling are tractor mounted rakes. Rakes move the vegetation readily and allow the dirt and ashes to sift through the teeth.



Figure 3-34. Clean, well compacted windrows prepared for burning.



Figure 3-35. Heavy duty brush burner.

Section V. PRODUCTION ESTIMATE

3-27. General

It is extremely difficult to establish specific rules of thumb or other guides for selecting land clearing equipment, and determining at what rate each type of equipment can clear land. There are simply too many variables involved. Factors such as type of vegetation, terrain, climate, and underfoot conditions, coupled with the purpose for clearing, quantity to be chard, and equipment capabilities and limitations directly influence the selection of equipment and the production rate for any specific clearing job. A number of steps should be followed in analyzing and planning a land clearing operation. This analysis, combined with good judgment and common sense, can result in a reasonable estimate of production rate and time required.

3-28. Project Analysis

a. The first step is a thorough study of the project requirements and specifications. This should include–

(1) Specific area to be cleared.
(2) Time available.
(3) Type of vegetation and degree of clearing required.
(4) Climate, rainfall, and topography data.
(5) Support operations.
(6) Security considerations.

b. After a thorough study of the project requirements, the sources of information, such as map and terrain analysis discussed in appendix F, should be researched. The next step is a personal reconnaissance of the area to determine all of the characteristic of the area which will affect the operation. General topography and soil conditions should be determined. Note the size and number of problem areas, such as steep slopes, rocks, or swamps, which would significantly affect production or require special techniques. These should be expressed as a percentage of the whole area. The study of the vegetation should include two or preferably three tree counts for each general type of vegetation within the area to be cleared. These tree counts should be recorded as follows:

(1) For secondary growth and undergrowth less than 30 centimeters (12 inches) in diameter, note whether sparse, semidense, or dense.

(2) For trees 30 centimeters (12 inches) and above in diameter at breast height or above buttresses, record separately the average number per acre in each of the following size ranges:

30 to 60 centimeters (1 to 2 feet) diameter
60 to 90 centimeters (2 to 3 feet) diameter
90 to 120 centimeters (3 to 4 feet) diameter
120 to 180 centimeters (4 to 6 feet) diameter

(3) Record the diameter of each tree above 180 centimeters (6 feet) in diameter in each plot and express an average number per acre. A more detailed description of the tree count procedure, and additional factors in making the analysis of the vegetation, are contained in paragraph F-9, appendix F. Tabulate the data obtained from this reconnaissance on a form similar to table 3-7, for use in determining production rate.

Table 3-7. Clearing Reconnaissance Form

Tree diameter	1'-2'	2'-3'	3'-4'	4'-6'	Above 6'
No. of trees/acre					
% Hardwoods					
Vines present? Yes or No					
Description of root system					
Description of undergrowth					
Description of soil					
End use of land					
Debris disposal method					
Soil conservation to be practiced					
Grade and terrain					
Water table conditions					
Rainfall					
Underfoot conditions					

c. The degree (scope, quality, and relative permanency) of clearing to be accomplished is usually dictated by the purpose or objective of the clearing operation. However, long-range implications should always be considered since it frequently is possible to

employ alternative techniques that can also fulfill long term requirements with little or no additional effort. This is especially true when considering clearing subsurface vegetation and piling the cut vegetation. After determining what items of equipment are capable of accomplishing the required clearing, production rates for each type should be determined. The following tasks include those which may be required to accomplish the clearing objective:

(1) Hand clearing.
(2) Shearing.
(3) Chaining.
(4) Spade plow.
(5) Rolling chopper.
(6) Harrowing.
(7) Piling.
(8) Grubbing.
(9) Burning.
(10) Shredding.

Figure 3-36 shows the area conversion factors from English to metric system for convenient use in calculating production rates.

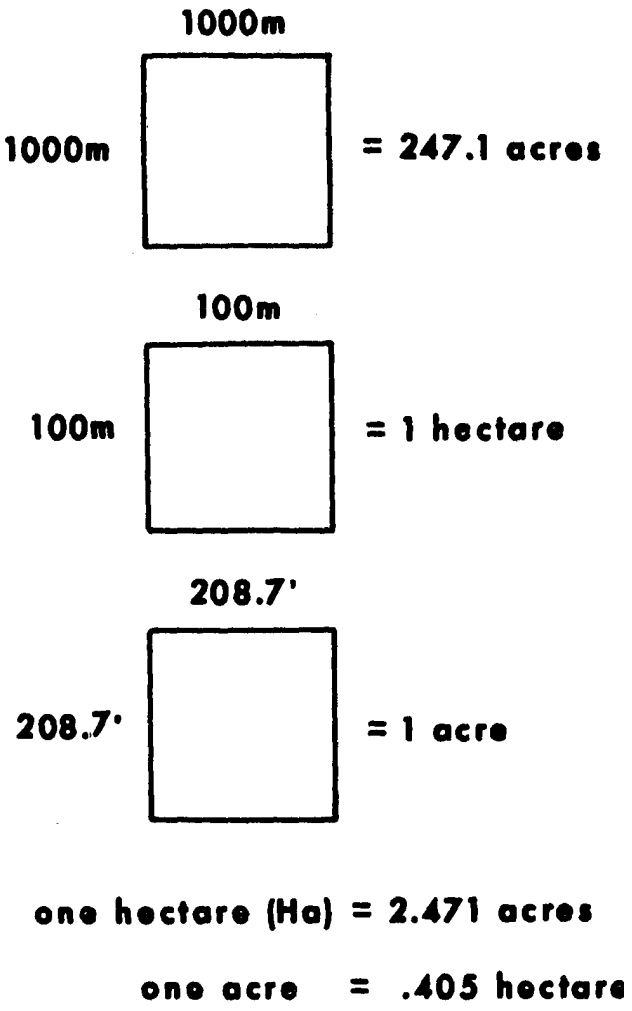


Figure 3-36. Area conversion.

3-29 Hand Felling

Without prior experience it is difficult to determine the ability of indigenous personnel to clear land. For average work output per man-hour, table 3-8 can be used as a guide. This data should be supplemented by records maintained by the unit wherever possible to obtain a more accurate estimate. The man-hours shown are for personnel directly engaged in the clearing task and do not allow for maintenance and other overhead personnel.

Table 3-8. Clearing By Hand

Operation	Unit	Man-hours per unit
Blasting with 3-man team	Tree	1.5
Light clearing (Brush and small trees).	Acre	125
Medium clearing (Trees 7''—12'')	Acre	350
Heavy clearing (Trees 12''—30'')	Acre	800
Light clearing, 10 meters wide	100 linear meters	25
Medium clearing, 10 meters wide	100 linear meters	70

3-30. Equipment Felling

a. Constant Speed Operations. The production rate of any clearing operation which is accomplished by a tractor moving at a relatively constant speed can be calculated by use of the American Society of Agricultural Engineers formula.

$$\text{Speed (mph)} \times \frac{\text{width of cut (ft)}}{10} = \text{acre/hr}$$

$$\text{Speed (kph)} \times \frac{\text{width of cut (m)} \times .825}{10} = \text{hectaes/hr}$$

This formula allows for 82.5 percent efficiency. This reduction is to allow for losses due to turning, etc. Figure 3-37 is a nomogram for calculating this formula. It can be used in estimating the production rate for roller chopping, harrowing, plowing, mowing, or any other relatively constant-speed operation. This formula can also be used for a rough estimation of chaining production. The width of cut would be the distance between the tractors. Since the width and the forward speed vary, an average must be used for estimating. The speed used in the formula must be the actual speed of the tractor. This must be measured, but since 88 ft/min. equals 1 mph, the lapsed time to travel 88 feet can easily be converted to mph. Several readings using a stop watch should be made for accurate speed determination.

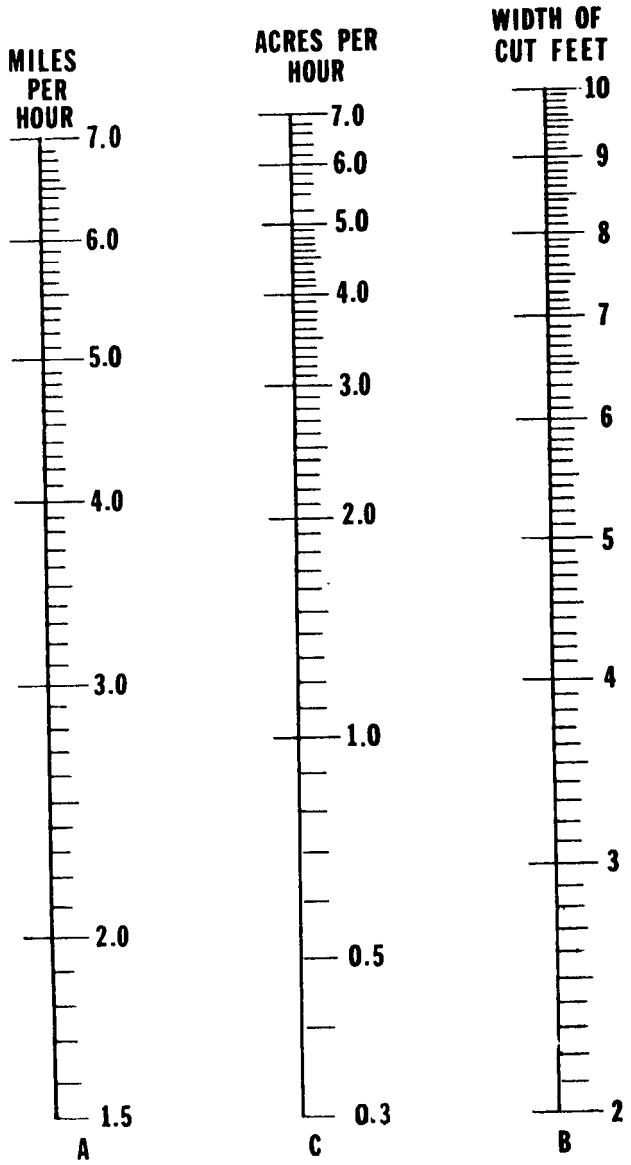


Figure 3-37. Agricultural engineers formula nomograms.

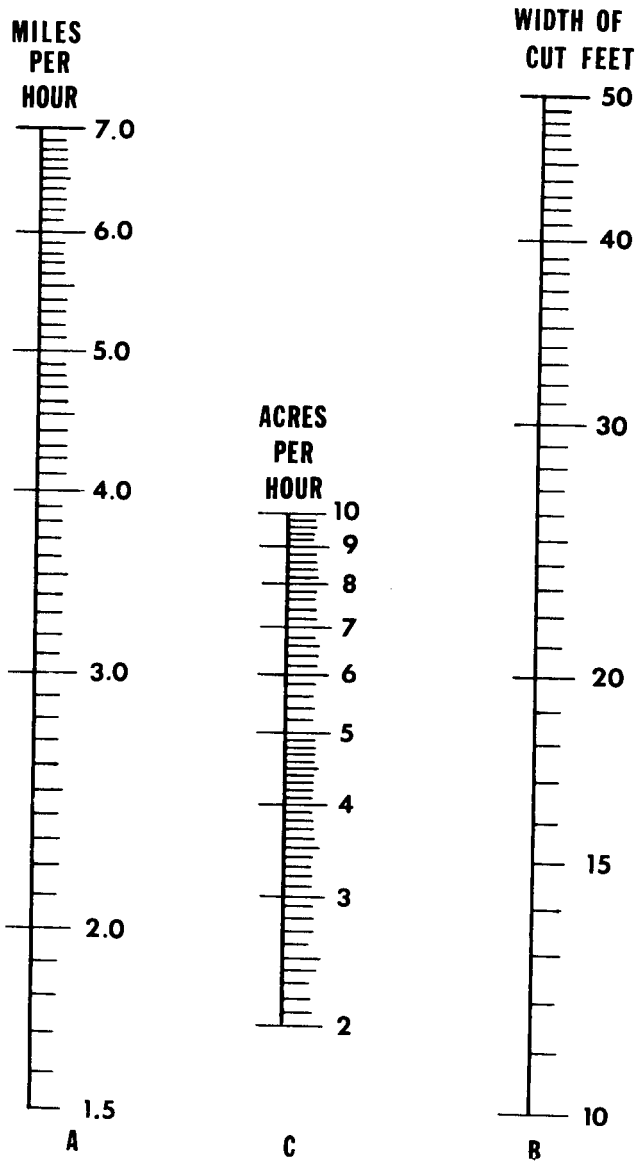


Figure 3-37—Continued.

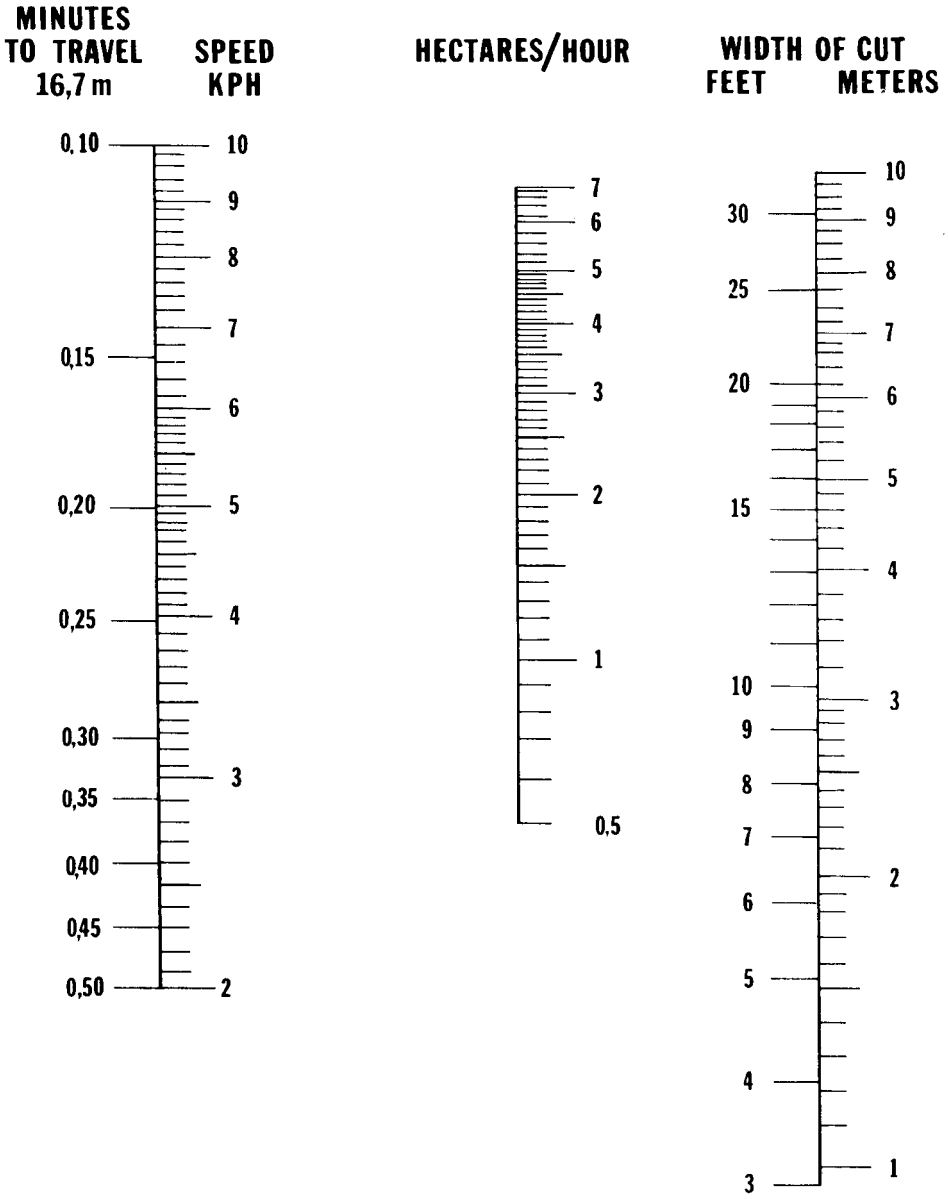


Figure 3-37.—Continued.

b. Shearing Blade. A formula for estimating cutting time per acre in minutes for tractors equipped with shearing blades has been developed. The formula incorporates many of the terrain and vegetation factors which affect land clearing production. It is based on a number of years experience in clearing all types of vegetation. The approximate number of tractor-hours per acre can be calculated by applying the factors shown below, together with the data obtained from the area reconnaissance, using the formula:

$$T = X[A(B) + M_1N_1 + M_2N_2 + M_3N_3 + M_4N_4 + DF]$$

where,

T = time per acre in minutes.
X = factors affecting total time.
A = factors affecting base time.
B = base time for each tractor per acre.
M = minutes per tree in each diameter range.
N = number of trees per acre in each diameter range obtained from a tree count.
D = sum of diameter in feet of all trees above 6' in diameter obtained from a tree count.
F = minutes per foot of diameter for trees above 6' in diameter.

Values for use in this formula are obtained from table 3-9.

Table 3-9. Shearing Production.

Tractor[1]	Base[2] "B"	Dia. range[3] 1'—2' "M_1"	Dia. range 2'—3' "M_2"	Dia. range 3'—4' "M_3"	Dia. range 4'—6' "M_4"	For dia. above[4] 6' per foot "F"
385 HP	18	0.2	.5	1.5	4	1.2
270 HP	21	0.3	1.5	2.5	7	2.0
180 HP	28	1.5	2.0	4.0	12	4
120 HP	40	0.8	4.0	8.0	25	

[1] Based on current model tractors (power shift when applicable) working on reasonably level (below 10 % grade) terrain with good footing and no stones in average mixture of soft and hard woods. Tractor is in proper operating condition, blade is sharp, and properly adjusted.

[2] The base figures represent the number of minutes required for each tractor to cover an acre of light material where no trees require splitting or other individual treatment.

[3] M represents minutes required to cut trees from 1 ft to 2 ft diameter at ground level. M same for trees in 2 ft and 3 ft diameter range. M same for 3 ft to 4 ft diameter range. M same for 4 ft to 6 ft diameter range.

[4] The figures in this column represent for each tractor size the number of minutes required per foot of diameter to cut trees above 6 ft in diameter. Thus, to fell an 8' diameter tree would require 8 x 1.2 or approximately 10 minutes with a 385 HP tractor.

The following factors should be applied in determining production for tractors equipped with a shearing blade:

Amount of hardwoods present—
- 75-100 % : increase total time by 30 % (X = 1.3)
- 25-50 % : no change (X = 1.0)
- 0-25 % decrease total time by 30 % (X = 0.7)

Density of undergrowth (less than 12' in diameter)

Dense—600 trees acre: increase base time by 100 % (A = 2.0)

Semidense—400-600 trees acre: no change (A = 1.0)

Sparse—less than 400 trees acre: decrease total time by 30 % (X = 0.7)

Heavy vines present: increase base time by 100 % (A = 2.0)

Soft underfoot conditions, rocky terrain, and slopes steeper than 10 percent will reduce tractor efficiency. These factors are too variable to give specific reduction factors. This formula was developed for use with the Rome K/G blade, but it will also apply to V blades attached to the same sized tractors.

c. Spade Plow. During the previous discussion of the spade plow, it was noted that this attachment could perform several operations. Table 3-9 has been developed for use with this attachment. The production rates shown in table 3-10 are based on good underfoot conditions, no heavy vines, and terrain slopes less than 10 percent. The production rate must be decreased if these adverse conditions exist in the cut area. The amount of time per acre is reduced if some of the operations such as root plowing (5) and/or raking (3) do not have to be performed.

Table 3-10. Production Estimate for Spade Plow

Mixed hardwood, 1' to 2' diameter + undergrowth

Tractor	1*	2	3	4	5	6	7	8	9	10
D-6 or equivalent	35	.7	.15	.18	1.18		100	153	2.55	.390
							200	271	4.52	.221
							300	389	6.48	.154
							400	507	8.45	.118
D7E or equivalent	28	.5	.1	.1	.12	.82	100	110	1.85	.544
							200	192	3.2	.313
							300	284	4.4	.227
							400	356	5.93	.169
D-8-46 or equivalent	24	.3	.075	.075	.1	.55	100	79	1.3	.77
							200	134	2.2	.454
							300	189	3.15	.320
							400	244	4.0	.25

* 1 Base time (minutes to cover 1 acre)
2 Time to fell (minutes to fell tree)
3 Time to rake (minutes to rake)
4 Time to pile (minutes to pile)
5 Time to plow (minutes to plow)
6 Total (minutes to complete operation)
7 Trees per acre
8 Total time to complete operation (in minutes)
9 Hours per acre
10 Acres per hour

d. Bulldozer. The bulldozer is readily available in most engineer units and can be used when specialized land clearing tools are not available. The following are average clearing rates for dozers.

	Tractor	
	Under 180 hp	*Over 180 hp*
Brush and small trees (6" or smaller).	1,000 sq m/hr	1.200 sq m/hr
Medium trees (7"–12") ...	3-9 min/tree	2-6 min/tree
Large trees (12"–30) ...	5-20 min/tree	5-20 min/tree

These clearing rates include removal of entire tree and stump and piling the trees in windrows.

3-31. Quick Estimates

Table 3-11 has been assembled for use in making quick estimates for area clearing and should be used only when a detailed reconnaissance and tree count are not possible. The production rates presented are for average areas, and adverse conditions can reduce these rates significantly. If quick estimates for strip clearing are required, multiply the time required per unit in table 3-11 by 1.6.

Table 3-11. Quick Estimates for Area Clearing

Method	Unit	Man-or equipment-hours per unit		
		Light * (less than 12")	Medium (12" to 18")	Heavy (18" *)
Handtools & chain saws	1000 sq m	22	53	77
Bulldozer				
a. Medium tractor (180 hp and less)	acre	2.5	5	10
b. Heavy tractor (more than 180 hp)	acre	1.5	3	8
Spade plow medium tractor	acre	1.33	2.2	3.9
Shearing blade				
a. Medium tractor	acre	.4	.8	1.3
b. Heavy tractor	acre	.3	.5	.8

*Maximum vegetation size.

3-32. Grubbing

When the job requires grubbing and piling of stumps, it is most efficient to accomplish this as a part of the initial felling operation. Grubbing is included in the production rates listed in paragraphs 3-30 and 3-31 for all types of equipment except the shearing blade. If grubbing is to be done using the angle shearing blade, it is most efficient to accomplish it as part of the initial felling operation (para 3-30b and table 3-9, also para 3-31, table 3-11). In this case the total time calculated by the cutting formula is increased by 25 percent (X = 1.25). If grubbing is to be done after initially cutting the vegetation at ground level, the total time is increased by 50 percent (X = 1.5).

3-33. Piling

The production rate for piling is calculated in a manner very similar to the way the cutting rate was calculated. This formula is used for estimating piling time per acre in minutes for a tractor equipped with a piling tool. To estimate tractor hours per acre on a specific land clearing job, apply the factors shown below, together with data obtained from the job cruise in the field, using the formula—

$$T = B + M_1N_1 + M_2N_2 + M_3N_3 + M_4N_4 + DF$$

where,

T = Time per acre in minutes.
B = Base time for each tractor per acre.
M = Minutes per tree in each diameter range.
N = Number of trees per acre in each diameter range obtained from field cruise.
D = Sum of diameter in feet of all trees per acre above 6 ft in diameter at ground level obtained from field cruise.
F = Minutes per foot of diameter for trees above 6 ft in diameter.

Values for use in this formula are obtained from table 3-12. All the rates are based on a single tractor operation. Where three or more tractors are working together in a fleet operation, production will increase

by 25 percent depending on the size and number of trees per acre. For quick estimates for piling use the following data:

		Equipment ours per acre		
Equipment	*Unit*	*Light*	*Medium*	*Heavy*
Medium tractor	Acre	.5	.8	1.2

Table 3-12. Production Table for Piling in Windrows.*

Tractor [1]	Base [2] minutes "B"	Dia. range [3] 1'—2' "M_1"	Dia. range 2'—3' "M_2"	Dia. range 3'—4' "M_3"	Dia. range 4'—6' "M_4"	For dia. above [4] 6' per foot "F"
385 HP	45	0.1	0.2	1.4	2.4	0.4
270 HP	50	0.2	0.6	2.0	4.0	1.0
180 HP	60	0.4	0.8	3.0	6.0	.....
120 HP	75	0.6	1.2	5.0	.....	.....

* May be used with most types of raking tools.

Windrows to be spaced approximately 200 feet apart.

[1] Production with tractor working alone based on current model tractors (power shift when applicable) working on reasonably level (below 10% grade) terrain with good footing and no stones in average mixture of soft and hard woods. The tractor is in proper operating condition. Decrease total time by 25-50 % depending on the number and size of trees, when using three tractors in combination.

[2] The base figures represent the number of minutes required for each tractor to cover an acre of light material.

[3] M_1 represents minutes required to pile trees from 1 ft to 2 ft diameter at ground level. M_2 same for trees in 2 ft to 3 ft diameter range. M_3 same for 3 ft to 4 ft diameter range. M_4 same for 4 ft to 6 ft diameter range.

[4] The figures in this column represent for each tractor size the number of minutes required per foot of diameter to pile trees above 6 feet in diameter. Thus, to pile an 8' diameter tree would require 8 x .4 or approximately 3.2 minutes with a 385 HP tractor. When piling grubbed vegetation, increase the total time by 25%.

3-34. Burning

When burning the cut vegetation in windrows, tractor time must be allowed for tending the fires and repiling the vegetation to insure a complete burn. Thirty minutes to 1 hour tractor time per acre is normally required to accomplish this task. No tractor time is required for burning in place, except when firebreaks must be constructed.

3-35. Special Areas

In addition to the production rate for normal clearing operation, the time required to clear special problem areas such as steep slopes, swamps, rocky areas, and streambanks must be calculated separately. Since the time required to clear these areas is even more variable than for normal clearing, personal judgment and experience may be the only basis for making an estimate.

3-36. Tree Blowdown

Tme blowdown caused by a nuclear burst produces a different situation from that of a natural storm. The area damaged by either a nuclear air burst or a surface burst varies according to the size of the weapon (bomb). The degrees of damage may be one or more of the following: total damage (90 percent or more, usually at or near ground zero), severe, moderate, and light. The damage becomes progressively lighter outward from ground zero. In addition to the tree blowdown caused by an air burst, a surface burst also produces a radioactive crater, induced radiation (mainly neutrons), and fallout. Blowdown clearance in a radiologically contaminated area requires more time and equipment because of the radioactivity. The machinery must be equipped with protective features which shield (at least partially) the operator from the harmful radiation. (For further information on tree blowdown in a nuclear environment, see TM 5-220).

CHAPTER 4

LANDING ZONE, REMOTE SITE AND CONSTRUCTION CLEARING

Section 1. LANDING ZONE AND REMOTE SITE CLEARING

4-1. Landing Zone Clearing

a. General. Landing zone (LZ) clearing is necessary to support airmobile operations in forested areas. Initially it may be only a one-helicopter LZ cleared from the jungle using demolitions and chain saws, but it can be developed into a large combat base in successive stages. When an infantry battalion is conducting an airmobile combat assault into a heavily forested area, the engineer platoon is often the first airlift into the landing zone, depending on whether or not security is already on the ground. Their mission is to initially clear the landing zone to allow one helicopter to land and then to bring in more equipment to improve and expand the landing zone.

b. Landing Zone Cutting Team.

(1) If an initial clear area is available, an engineer landing zone cutting team can establish an LZ by descending into the site with its jungle cutting equipment from a hovering Chinook (CH-47) helicopter (fig 4-1), after the area has been secured by ground forces. This team must be extremely well trained and each mission well planned. A reconnaissance of the proposed LZ should be made by an engineer officer or NCO if time permits. As a result of this reconnaissance, the tools and equipment necessary to be taken to the LZ may be selected in order to provide the best tools for the specific type of vegetation to be cut. For example, bamboo is most effectively leveled with bangalore torpedoes. Typical items of equipment taken into the LZ are ammunition, machetes, brush hooks, chain saws, two-man crosscut saws, axes, potable water, C-rations, premixed gasoline for chain saws, oil for chain saw lubrication, demolition bags, C-4 plastic explosive, bangalor torpedoes, detonating cord, sharpening equipment for tools, mechanics tools for chain saw repair, and chain saw repair parts. This equipment is prepacked in two sling loads, and a third load for resupply containing additional explosives is prepacked for on-call delivery. Immediately upon arrival at the mission site, the team leader coordinates with the tactical commander on the ground to establish work priorities and to explain demolition safety and procedures.

(2) A second method of inserting a platoon or squad sized engineer landing zone cutting team into an area is by rappelling from a hovering utility or troop carrier. The team must have had prior training in rappelling practice in actually using helicopters. The rappel from the helicopter is made using a rope, and a "Swiss" seat- **O** -ring arrangement. Gloves are worn to avoid rope burns and only essential equipment is taken on the initial insertion. This consists of weapons and ammunition, chain saws, demolition bags, C-4 plastic, explosive, machetes, premixed gasoline, oil, C-rations, and water. After a one-s hip LZ has been cut, more equipment and men are inserted. There must always be close coordination between the team leader, the helicopter pilot, the pilots of any gunships accompanying the mission, and the ground security forces. In comparing this method of insertion with the method using a Chinook (CH-47) and a rope ladder there are certain advantages. The insertion by rappel is a faster method and gets the team on the ground faster. This is important when rappelling under hostile fire into a "hot" LZ. Also, there is less chance of single ropes getting entangled in trees as compared to a rope ladder. This becomes significant when establishing an LZ in double or triple canopy jungle or very thick forest. The advantage of using the Chinook is that it can carry more troops on a single sortie.



Figure 4-1. Combat engineer landing zone clearing team descending from a hovering Chinook (CH47).

c. Demolition Techniques. Demolitions used in landing zone clearing are C-4, TNT, detonating cord, and bangalore torpedoes. The C-4 and detonating cord are used for felling trees and are the two items that account for the bulk of the demolitions. When C-4 is not available, TNT is an acceptable, yet less desirable, substitute. Because external charges are used, the approximate weight of C-4 is only 70 percent of the weight of TNT required to accomplish the same task, so there is less to transport. Also, C-4 is faster and easier to place than TNT and can be molded around trees for more effective results. Charges are placed approximetely 4 to 5 feet above the ground where the tree has thinned down to the nominal diameter and not at the tapered root section or buttress. The remaining stumps are removed or cut down with chain saws or other techniques where their presence will interfere with intended usage or expansion of the LZ. In dense forest, up to 100 trees are prepared at one time and are detonated simultaneously using a detonating cord ring main. Nonelectric caps are preferred over electric caps to eliminate the potential hazard of radio signals detonating an electric cap prematurely. However, if helicopters are resupplying an LZ while it is still being expanded and improved, the explosives create a precarious situation for the incoming helicopters. Even with good communications there are often problems. For this reason electric caps may be preferred because the exact instant of detonation can be controlled using electric caps and a blasting machine. The quantity of C-4 and detonating cord required for clearing a landing zone varies with the type and density of vegetation and with the size of the area required. A "rule-of-thumb" which relates the number of pounds of C-4 to feet of detonating cord has been developed. For dense vegetation (triple canopy, average tree diameter between 12 and 36 inches), 1 foot of cord is required per pound of explosive; for light vegetation, 2 feet of cord per pound of explosive. Bangalore torpedoes are used extensively to clear dense bamboo growth. The shrapnel from the torpedo casing is extremely effective in leveling bamboo with stalk diameters up to 6 inches. The pattern used is to place bangalore torpedoes in parallel lines spaced at 10-foot intervals throughout the area of bamboo.

d. Employment of Large Clearing Munitions. One effective innovation for the crest ion of helicopter landing zones (HLZ) has been the use of large aerially delivered munitions to knock down trees and other vegetation and thereby create an initial opening suitable for creating a landing zone for use by helicopters. The technique of using a single large conventional explosive charge for clearing HLZ in dense forested areas has been found to be highly satisfactory.

(1) Landing zones may be classified according to the ability of a given helicopter to utilize the site. Full touch zones (FTZ) permit a complete landing, skid touch zones (STZ) require that the helicopter support most of its weight by the rotor, and non-touch zones (NTZ) allow no more than a hover. Because of the uncertainty associated with the initial size and postblowdown condition of the clearing, all "bombed" sites should be tentatively classified for planning purposes as nontouch zones.

(2) An M121 (T56E4) concussion-type bomb of 3.6 metric tons (10,000 lb) explosive charge was used previously during tests. Another weapon of 6.6 metric tons (15,000) is presently available and one of 4.5 metric tons. (12, 195 lb) is under development. The M 12 l-type has been dropped from C-130 and CH-54 aircraft; a good view of the assembly may be seen in figure 4-2. A fuse extender mounted on the bomb nose is designed to detonate the munition about one meter above ground, thereby achieving maximum vegetation blowdown while minimizing undesirable soil cratering. A stabilizing parachute, tail fuse, and metal shroud placed around the tip of the fuse extender are designed to insure that the bomb penetrates the vegetative canopy and detonates as planned.



Fig 4-2. CH-54 with M121 clearing munition en route to target.

(3) Soil cratering effects appear to be nominal. At one test site the maximum depth and diameter were approximately 64 centimeters and 14 meters, respectively; but beyond about 5 meters from ground zero (GZ) cratering was insignificant. At another test site cratering was also nonexistent or insignificant. Consequently, soil cratering has been assumed to be of no consequence to helicopter operations when these large munitions are employed.

New fusing procedures also help by initiating detonation from both ends of the explosive charge, thereby minimizing cratering effects while maximizing blowdown forces exerted outward.

(4) Tree blowdown is characterized by the upper portion of the tree generally being separated and carried away from the lower portion by the shock wave. The break is seldom clean and wood splinters protrude above and below the point where failure begins. In the area within a 5 meter radius of ground zero tree failure occurs close to the roots. The stems and crowns of the trees are destroyed and carried out of the area by the blast, giving the ground a clean appearance. At greater distances, out to a radius of about 25 meters, lass vegetation is removed. Tree failure occurs at greater heights, producing taller remnants. Also, debris (branches, leaves) accumulates on the ground between the remnamts, producing a littered appearance. Thus, stump height increases with increasing distance from ground zero. and the amount of debris littering the ground increases also. Experience with air-delivered clearing munitions indicates that engineer troops must often enlarge and clean up this blowdown area to make it fully usable for helicopter operations.

(5) Figure 4-3 shows an aerial view of the clearing effects produced in a test which may help the reader visualize the effects of clearing munitions on forested areas. This test detonation produced almost total removal of vegetation out to a distance of 10 to 20 meters from GZ and significant damage up to distances of 40 to 60 meters. Table 4-1 presents some of the limited results available from tests which were conducted.

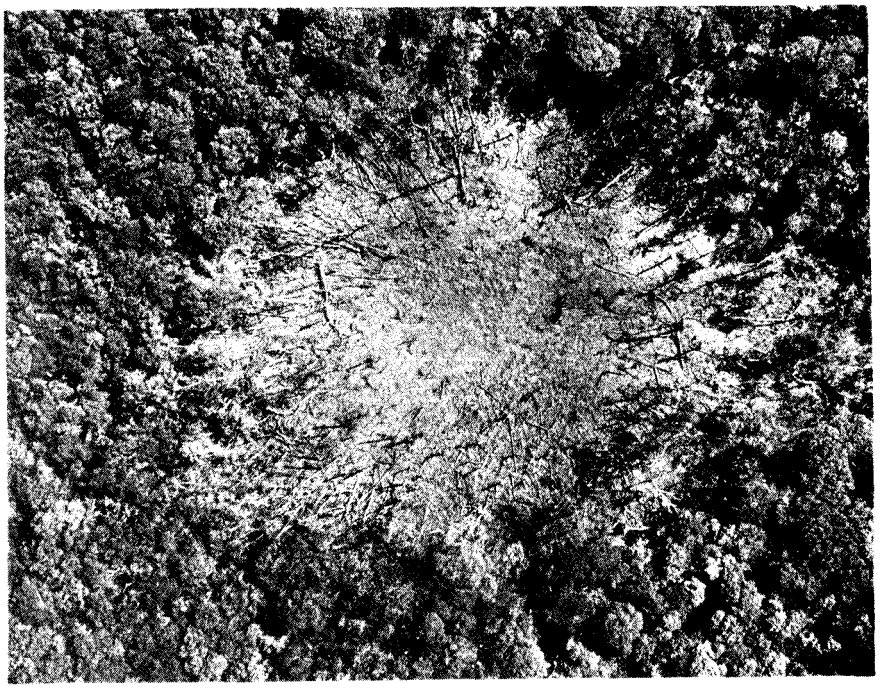


Figure 4-3. Aerial view of test site.

Table 4-1. Tree Remnant Heights for Test Detonation of M121 Munition (3.6 metric ton TNT yield)

Site No.	Local topographic slope (degrees)	Min radius, in m, of area cleared of obstacles 0.3 m	2 m	4 m	Maximum approach angle (degrees)	Category of HLZ constructed
FB-01	1	5	11	12.5	37	FTZ
SVN-01	9	11	23	25.0	32	FTZ
SVN-02	37	7	9	≥ 9.0	(*)	None
SVN-03	45	11	14	≥14.0	(*)	None
SNV-04	6	11	17	27.5	44	FTZ
SVN-05	9	0	11	14.0	(*)	NTZ
SVN-06	15	(**)	(**)	(**)	(*)	None
SVN-07	7	(**)	(**)	(**)	(*)	None
SVN-08	11	10	24	≥ 24.0	(*)	STZ

* No data, but the maximum approach angle in all cases was less than 75 deg.

* * .Large boulders and / or tree remnants ranging from 3 to 8 m in height were present at or near GZ.

(6) It is clear that several munitions might be employed to create a larger HLZ capable of accommodating several aircraft or of improving the approach and departure zones for one site. In such cases, these devices should be detonated no more than 24 meters apart. Accurate placement becomes essential and may not be attainable by drops similar to the past operational tests where CH-54 and C-130. aircraft flew at altitudes 1850 meters or higher above the terrain and at relatively high air speeds.

e. Chain Saws. Chain saws are used for cutting down standing timber up to 16 inches in diameter, but the major portion of their job in clearing a landing zone is to cut timber previously felled by demolitions. Fallen timber is sawed into lengths which permit manual clearing of the area. Timber may also be cut into lengths for later use in field fortifications, gun pads, or other facilities in the LZ. Chain saws are totally ineffective in cutting bamboo. The pulp clogs the chain assembly and it must be disassembled and cleared after only one cut. Shrapnel from preparation fires causes chain saw maintenance problems because hidden pieces of steel cause broken and dull chains.

4-2. Fire Support Base Clearing

a. General. Often in the sequence of an airmobile operation, a landing zone is developed into a fire support base (FSB) by enlarging it to accept the unit's mortars and eventually support artillery.

b. Layout and Planning. The siting of the heaviest artillery should be given first priority in the layout of an FSB. It must be reasonably level and free of stumps, and require a minimum of clearing in the principal direction of fire. The engineer should coordinate closely with the artillery commander because often a small shift in gun positions can significantly increase or decrease the amount of clearing required to eliminate the tree mask. The engineer should be prepared to build and assist in building overhead cover and bunkers for all personnel, ammunition, and equipment on the fire support base. The same equipment as used to cut an LZ should be taken as well as shaped and cratering charges to blow holes for underground bunkers.

c. *Airborne Equipment.* Clearing an FSB in a heavily forested area at a site inaccessible by surface movement using manual techniques is difficult and slow. When available, lightweight sectionalized airmobile crawler tractors equipped with land clearing or bulldozer blades should be deployed to the FSB site by heavy-lift into two sections. It requires two sorties by a CH-54 to accomplish the lift. Another tractor that can be helilifted into the base is the "mini-dozer" or 10,000-pound airmobile (MIL-T-52510/MD) tractor. It can be helilifted into the base in one piece using one sortie. The capabilities of these small tractors should not be overestimated, but they can speed up the construction of the FSB significantly. They can level bamboo, cut small trees, move large fallen timber, and dig emplacements as well as do rough grading and leveling of the FSB site. As can be seen in table 3-9, the production rate of this light tractor with a shearing blade decreases rapidly in vegetation above 12 inches in diameter, so explosives or chain saws should be used for the larger vegetation.

4-3. Base Camp Clearing

Normally, large base camps are developed along major lines of communication (LOC) and are cleared during the initial construction of the LOC or like area clearing as described in chapter 2. The major problems encountered at these fixed installations are the initial clearing and maintenance of fields of fire. Because long term clearing is required, the most complete job possible must be done initially, especially in the belts where barbed wire, mines, or trip flares are to be installed. Weeds and brush growing up through these obstacles are almost impossible to clear without completely removing and reinstalling the obstacles. If these areas are disked or thoroughly cleared with a rolling chopper prior to installing the obstacle the problem will be reduced. Herbicides can also be used to retard regrowth. When totally clearing or disking slopes greater than 10 percent, erosion control measures must be taken. Dust control and a reseeding program must be established in cleared areas near airfields and heliports. Complete clearing to bare soil should be avoided around these facilities. The maintenance of fields of fire is best accomplished with a mower once a good stand of grass has been established.

Section II. CONSTRUCTION CLEARING

4-4. Introduction

Land clearing as a construction operation consists of clearing a designated area of all trees, brush, other vegetation, and rubbish; removing surface boulders and other material embedded in the ground; and disposing of all the material cleared. Grubbing is the uprooting and removing of roots and stumps. Stripping is the removal of the organic topsoil and sod. Clearing operations to facilitate construction work normally include clearing and grubbing and

may include stripping, whereas tactical land clearing, described in chapter 2, usually only requires felling of the vegetation. Although the area cleared for construction is usually smaller than that required for tactical purposes, the specifications are much more stringent so the amount of effort expended per acre is considerably greater.

4-5. Requirements

The constructing agency or unit is responsible for determining the clearing requirements that are part of the construction mission. Often in tactical support construction missions, tactical clearing adjacent to the construction project will be accomplished in conjunction with the construct ion clearing. This is especially true for tactical road construction where a strip 200 to 500 meters wide is cleared to tactical clearing specifications while the center area where the road is to be built is cleared, grubbed, and stripped at the same time to facilitate construction.

4-6. Specifications

Because of the effort required and the erosion and duet control problems created by total clearing, only the minimum amount of clearing, consistent with the tactical and construction requirements, should be accomplished. Removal of the sod cover, especially around airfields, should be avoided whenever possible. Clearing, grubbing, and stripping are required in all cut or borrow pit areas, and in fill areas of less than 4 foot depth. In fill areas greater than 4 feet, normally just surface vegetation is cleared. If the specifications permit and deep fills are to be constructed, significant time and effort can be saved by shearing the vegetation in these fill areas at ground level and grubbing only in the cut and transition areas. Clear areas and approach zones adjacent to runways and heliports normally do not require that subsurface vegetation be removed (often even piling is unnecessary — see fig. 4-4). Rights-of-way for powerlines and pipelines also require only surface clearing.

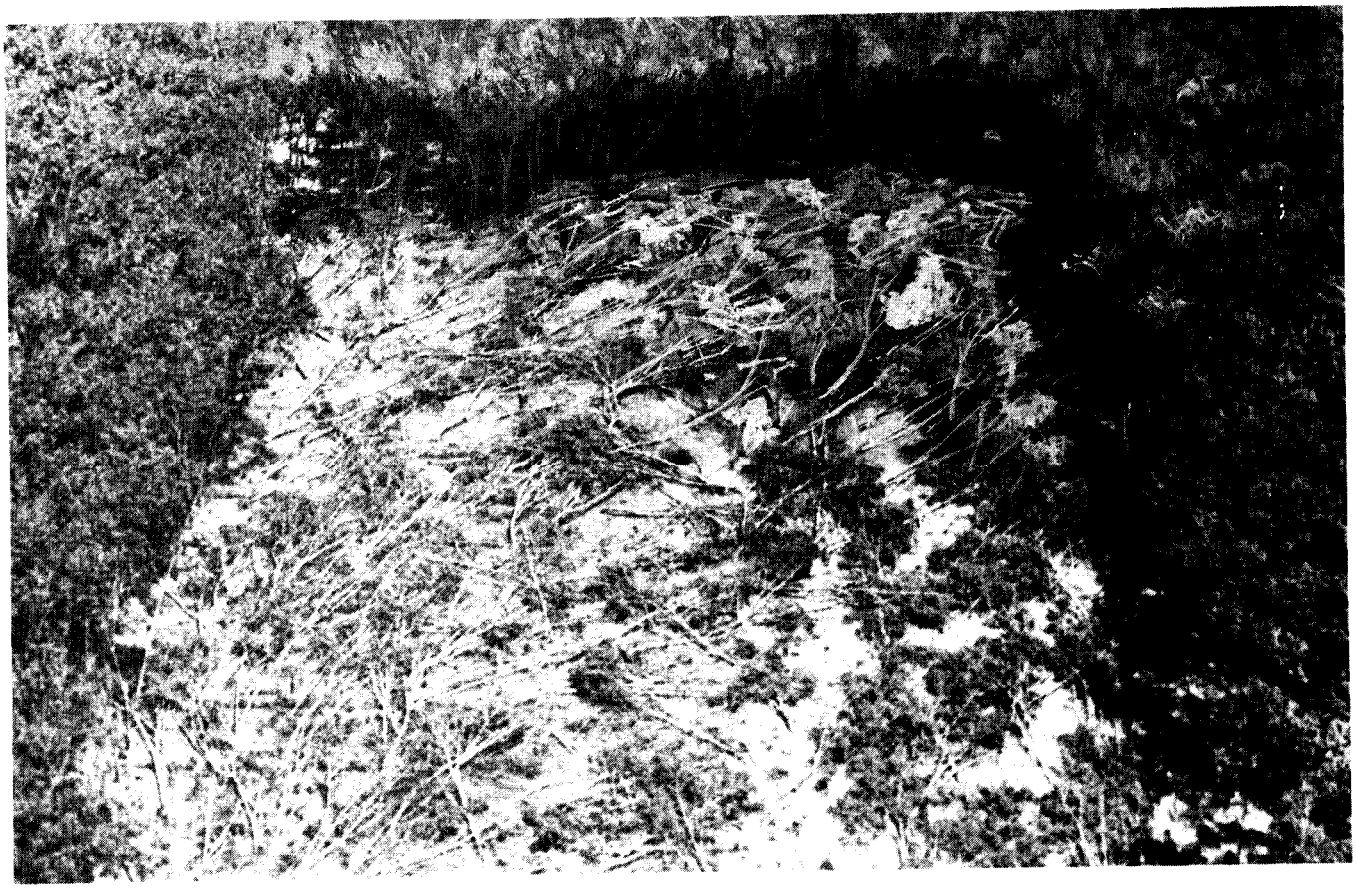


Figure 4-4. Trees felled at end of runway to provide better glide angle for incoming aircraft.

4-7. Techniques

The basic patterns of movement and organization of the clearing area used for construction clearing are the same as those described in chapter 2 for area or strip clearing. Because the areas are small compared to those in tactical clearing the bulldozer is often the most practical and available tool. It can be immediately used for earthwork without changing the blade. A motor grader or scraper can be used for clearing and stripping of light vegetation less than 2 inches thick. It may also be used for stripping turf for sodding bare areas. When the stumps are to be removed, the tree should be uprooted initially rather than cut so that the added leverage of the standing tree can assist in removing the roots. The bulldozer, spade plow, tilted Rome K/G blade, and knockdown beam are the attachments most frequently used in construction clearing and grubbing. When clearing in a rainy climate, all holes in the soil formed by uprooting the trees should be filled immediately after felling the tree to prevent saturation of the subgrade. Phased development of the drainage system in the early stages of clearing, grubbing, and stripping is essential to insure uninterrupted construction. For disposal of cleared materials, waste areas or burning methods are used, depending on the type of construction, location, and amount of time. Generally, the material is pushed and skidded off the construction site and into the surrounding timber to speed disposal and to keep the area cleared for equipment operation. In all cases, the disposal should be done as rapidly as possible by assigning specific units of equipment to accomplish this operation concurrently with the clearing and grubbing. The type of disposal method selected should be consistent with the methods of camouflage, salvage, and drainage used for the clearing operation. In forward combat areas where the saving of time is essential, the quickest and most convenient method of disposal of all materials is to pile or dump the materials adjacent to the work area. A study of the construction plans will show where the debris can be piled without interfering with drainage or possible work areas. In the construction of the main project, it may become necessary to clear a portion of adjacent land for use in disposing of the cleared material. This clearing for disposal of debris should be located as close to the main project as possible to shorten the hauling distance. Timber useful for logs, piles, and lumber is trimmed and stockpiled for future use in bridge, culvert, and other types of construction. This type of timber is pushed or skidded into a salvage area from which it can be later removed to a sawmill with little difficulty.

APPENDIX A

REFERENCES

A-1. Army Regulations (AR)

115-11	Army Topography.

A-2. Field Manuals (FM)

3-3	Tactical Employment of Herbicides.
3-12	Operational Aspects of Radiological Defense.
3-22	Fallout Prediction.
5-15	Field Fortifications.
5-25	Explosives and Demolitions.
5-34	Engineer Field Data.
5-142	Nondivisional Engineer Combat Units.
20-22	Vehicle Recovery Operations.
21-26	Map Reading.
21-41	Soldiers Handbook for Defense Against Chemical and Biological Operations and Nuclear Warfare.
30-10	Military Geographic Intelligence (Terrain).

A-3. Technical Manuals (TM)

5-220	Passage of Obstacles Other than Minefields.
5-330	Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations.
5-331A	Utilization of Engineer Construction Equipment-VOL A: Earthmoving, Compaction, Grading and Ditching Equipment.
5-331B	Utilization of Engineer Construction Equipment-VOL B: Lifting, Landing and Hauling Equipment.
5-331C	Utilization of Engineer Construction Equipment-VOL C: Rock Crushers, Air Compressors and Pneumatic Tools.
5-331E	Utilization of Engineer Construction Equipment-VOL E: Engineer Special Purpose and Expedient Equipment.
5-333	Pits and Quarries.
5-342	Logging and Sawmill Operation.
5-461	Engineer Handtools.
5-725	Rigging.
5-3830-236-12	Operator's and Organizational Maintenance Manual Including Repair Parts and Special Tool List: Treedozer, Tractor Mounting: For Mounting on Tractor, Caterpillar Model D7E or Allis-Chalmers Model HD16: (Rome Plow Model KG7EM) FSN 3830-933-5458.
5-3830-237-12	Operator and Organizational Maintenance Manual Including Repair Parts and Special Tools List For: Treedozer, Tractor Mounting, for Mounting on Tractor, Caterpillar Model D7E (Rome Plow Model, KG7ED) FSN 3830-935-7981.
30-245	Image Interpretation Handbook, (NAVAIR 10-35-685; AFM 200-50).
30-245A	Image Interpretation Handbook, Vol. 2 (U) (NAVAIR 10-35-685; AFM 200-50).
30-246	Tactical Interpretation of Air Photos (NAVAER 10-35-613).

A-4. Table of Organization and Equipment (TOE)

5-87	Engineer Land Clearing Company.

A-5. Films (TF)

5-4624	Large Scale Land Clearing Operations,

APPENDIX B

OPERATOR AND EQUIPMENT PROTECTIVE DEVICES

B-1. Equipment Protection

In large vegetation, a land clearing tractor is constantly subject to being struck by falling trees. Hydraulic control mechanisms are vulnerable to severe impact loads so the lift cylinder lines and tilt cylinder lines on bulldozer blades must be well protected (fig B-1 and B-3). In addition, heavy radiator grill guards are necessary to prevent tree branches or bamboo from puncturing the radiator. The heavy duty louvered radiator grill guard shown in figure B-1 provides protection for the standard grill and radiator without impeding the airflow. Grill guards of perforated steel plate or cutout steel plate as shown in figure B-2 can be used as expedients, but these devices severely impede the airflow through the radiator which may cause overheating. Because the debris in the form of leaves, twigs, and brush is thrown into the air around the engine and radiator, a blower type fan is essential to keep the front of the radiator clear. Perforated engine side panels with hinged inspection and cleanout doors, shown in figure B-3, must be installed to prevent leaves and twigs from collecting around the engine and on the back of the radiator core. An air breather extension, in the form of a remote air intake, pipes clean air to the engine from inside the cab and will prevent falling leaves and debris from clogging the air breather filter element, shown in figure B-4. Heavy duty crankcase guards or belly pans must also be installed on a land clearing tractor to prevent damage from stumps.

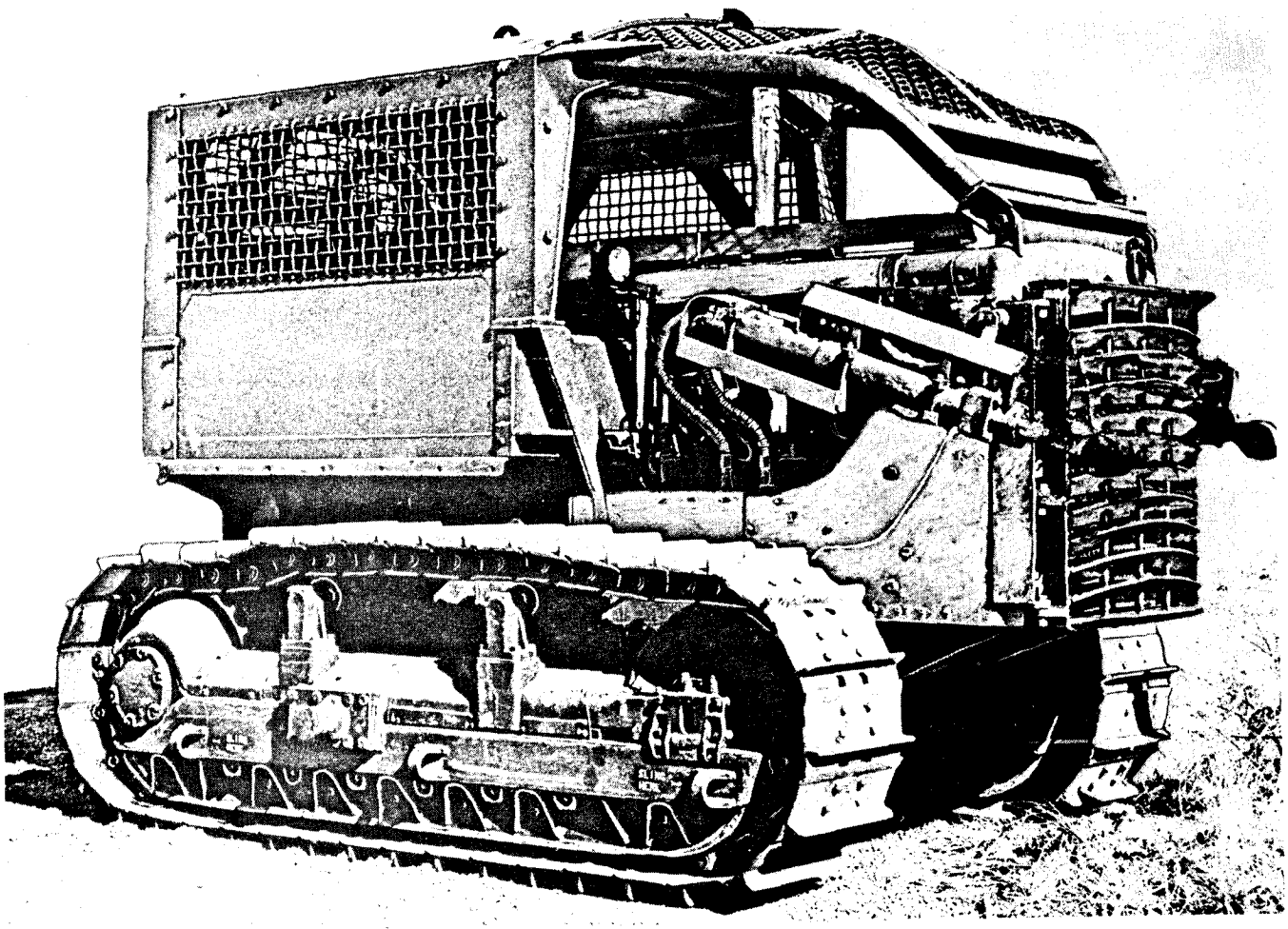


Figure B-1. D7E clearing tractor. Equipped with hydraulic lift cylinder protection, louvered radiator grill guard, remote air intake, and extra heavy duty jungle clearing cab.

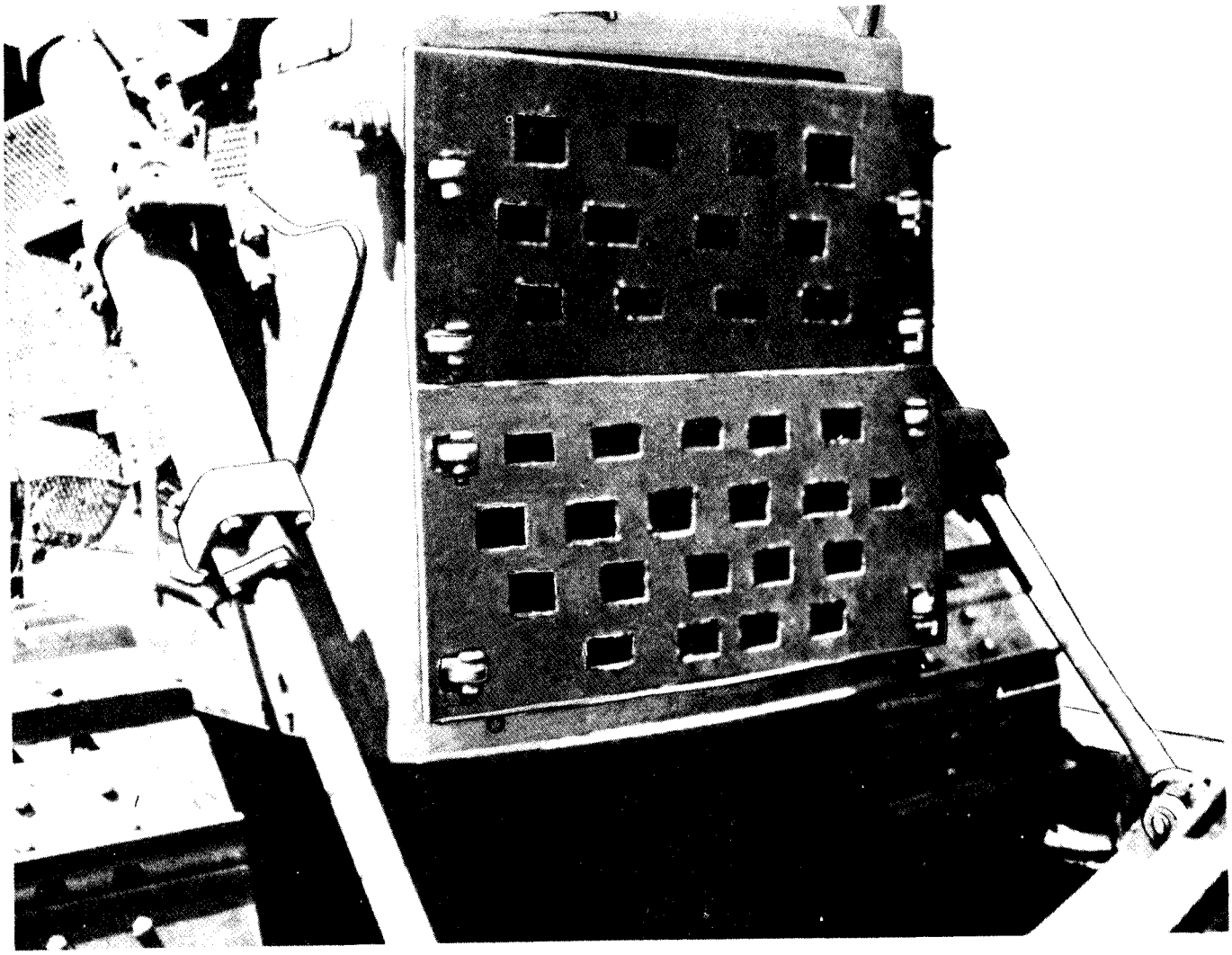


Figure B-2. A cutout steel plate used for expedient radiator protectior. This device severely restricts airflow through tie radiator.

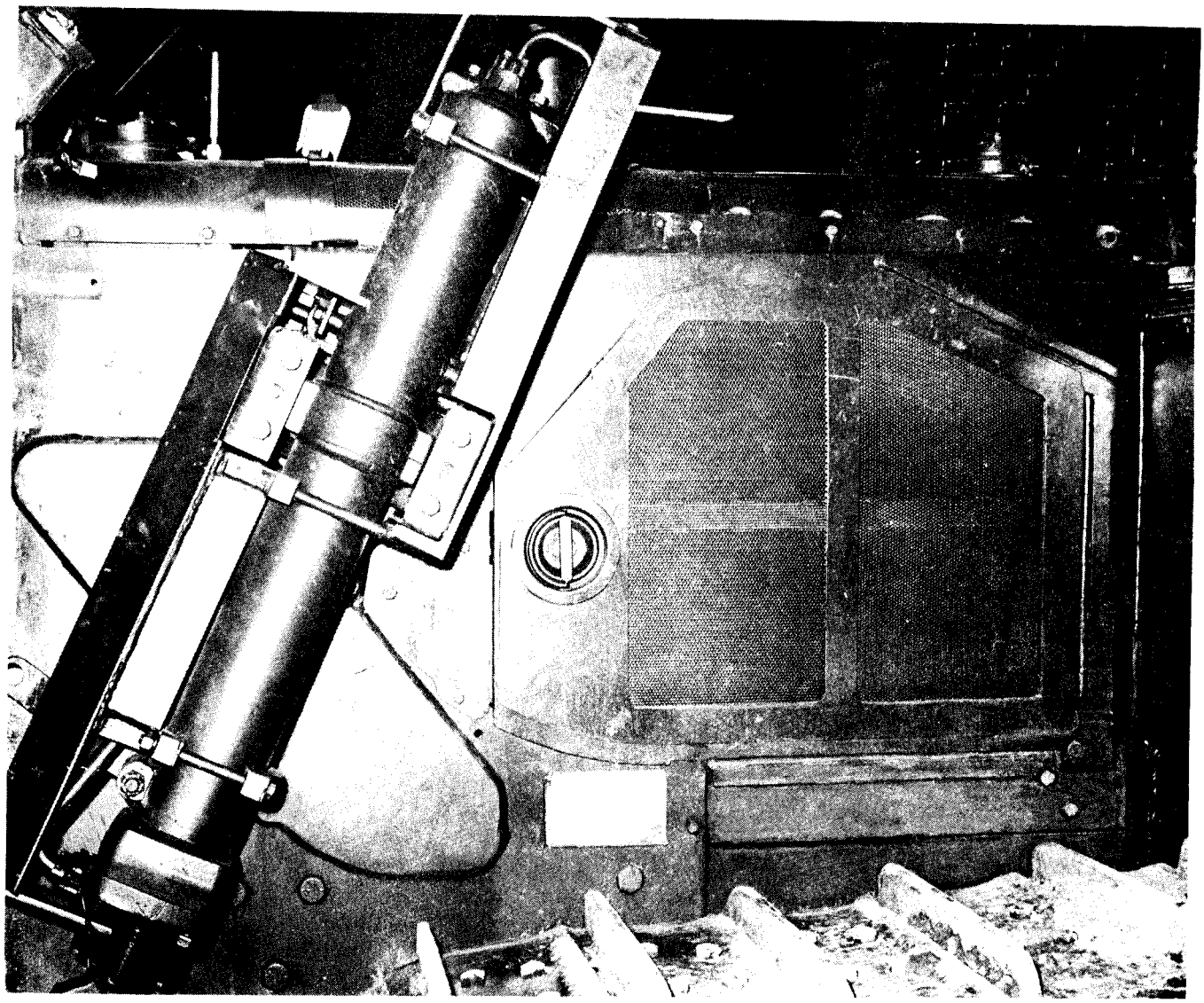


Figure B-3. Detailed view of engine side panels and hydraulic lift cylinder protection.

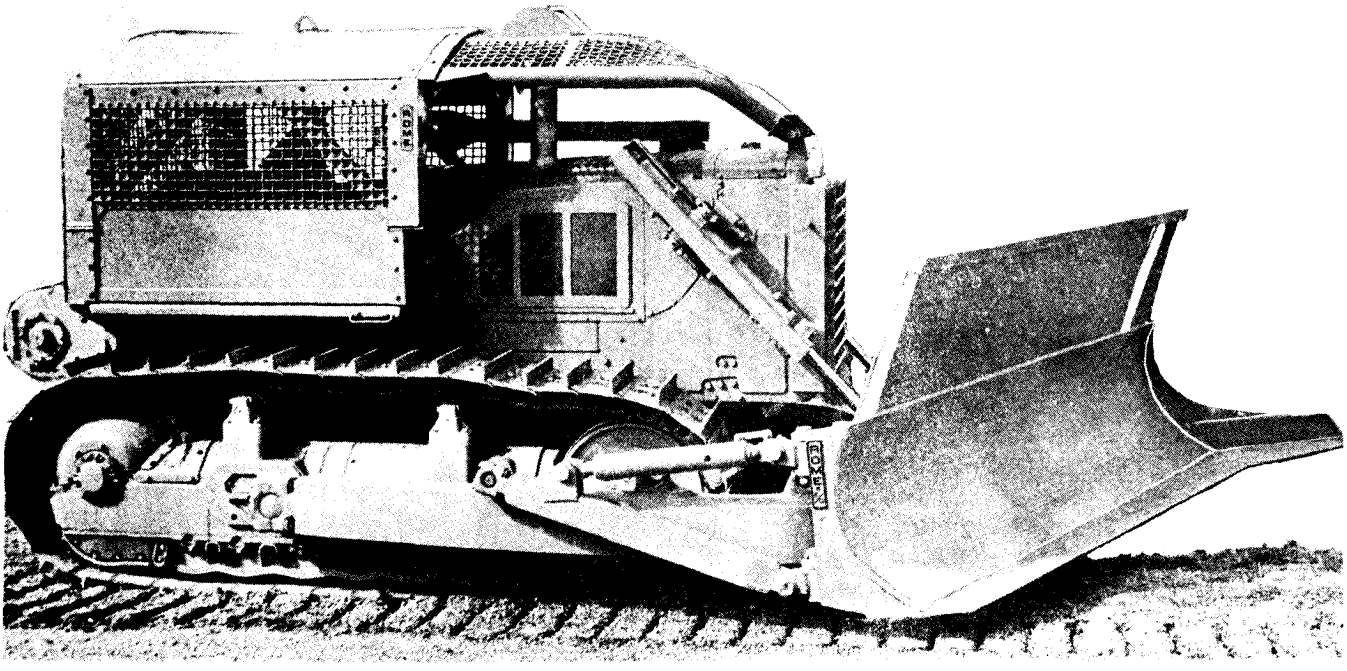


Figure B-4. D9G clearing tractor equipped with perforated engine side panels, hydraulic lift cylinder protection, louvered radiator grill guard, remote air intake, extra heavy duty jungle clearing cab, and Rome K/G shearing blade.

B-2. Operator Protection

When clearing all but the lightest vegetation, land clearing tractors and operators must be well protected. A heavy duty cab guard is essential. The original Army cab guard for use on land clearing tractors (fig B-5) proved to be inadequate for the severe operating conditions found to exist in the heavy monsoon forests of Vietnam. An extra heavy duty jungle clearing cab (fig B-6) was developed for use in these extreme conditions. The cab is constructed with high strength fabricated arches and is mounted directly to the frame of the tractor. It contains a water tank built into the top of the cab, equipped with a water pump and a hose for use in extinguishing bellypan fires and for emergency radiator water supply. The cabs have deflector bars extending forward to the grill to protect the engine compartment. Heavy screening is installed around the cab to protect the operator from brush. In some areas it may also be necessary to install insect screening on the inside of the cab to protect the operator from the painful and harmful stings of insects, such as bees and hornets. Operators should be equipped with seatbelts when operating in extremely rough terrain. The extra heavy cab is strong enough to protect the operator if the tractor rolls over.

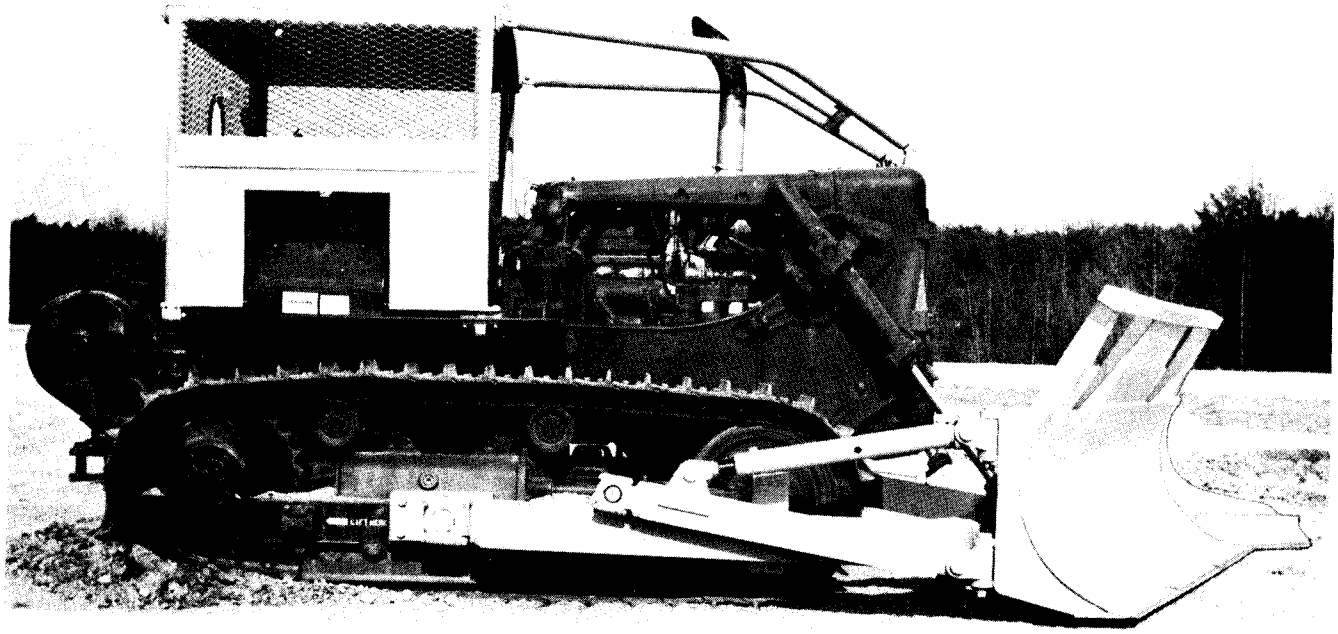


Figure B-5. HD-16 clearing tractor with initially designed protective cab and Rome K/G shearing blade.

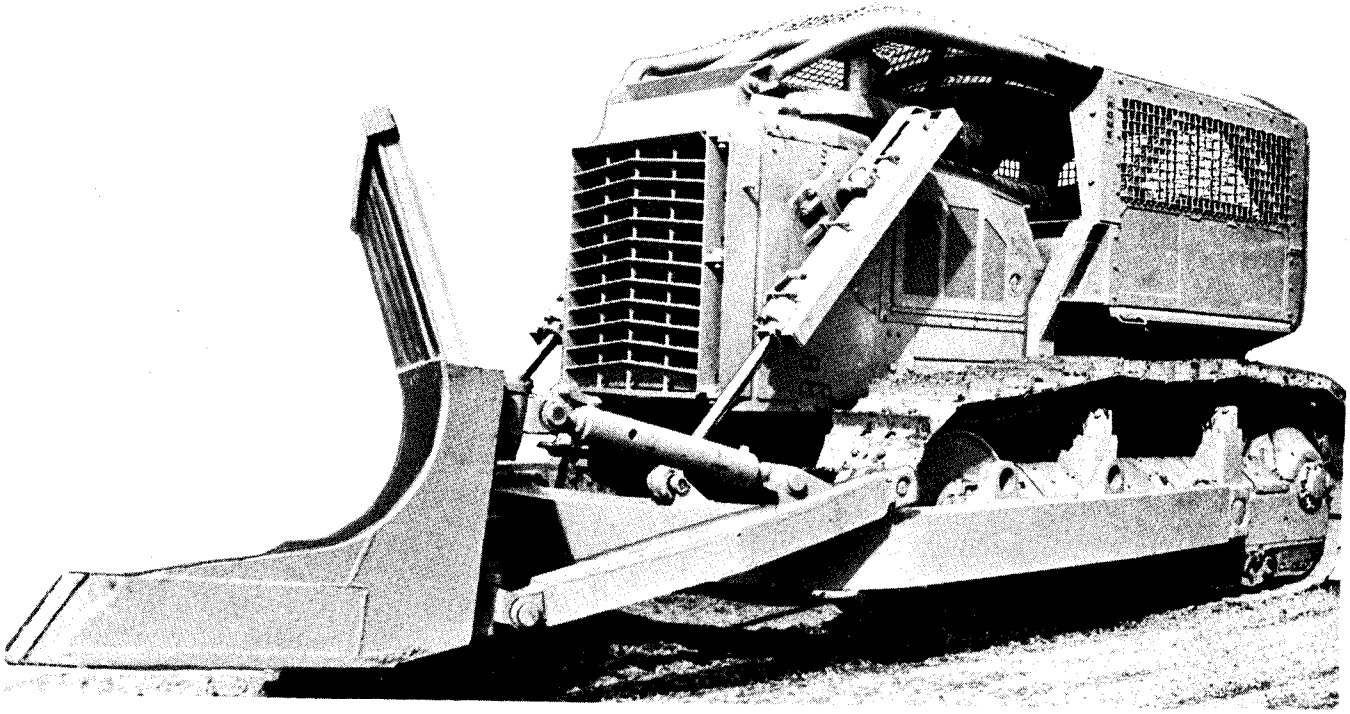


Figure B-6. D9G clearing tractor completely equipped for land clearing with extra heavy duty jungle clearing cab.

APPENDIX C

RECOVERY OPERATIONS

C-1. General

Land clearing tractors because of the limited visibility due to underbrush and soft underfoot conditions can frequently become high centered on stumps, logs, rocks, dry ridges, or mire. In this position, the tractor is helpless because both tracks are held clear of the ground and cannot get enough traction to move the tractor. Underground fortifications often cave in under the weight of the tractor, high centering it, (fig C-1). Sometimes the stinger can become so firmly stuck in a sound tree that raising and lowering the blade will not free it and the tractor has insufficient traction to back away. All of these situations require some means of recovery utilizing either the tractor mounted winch or a recovery vehicle.

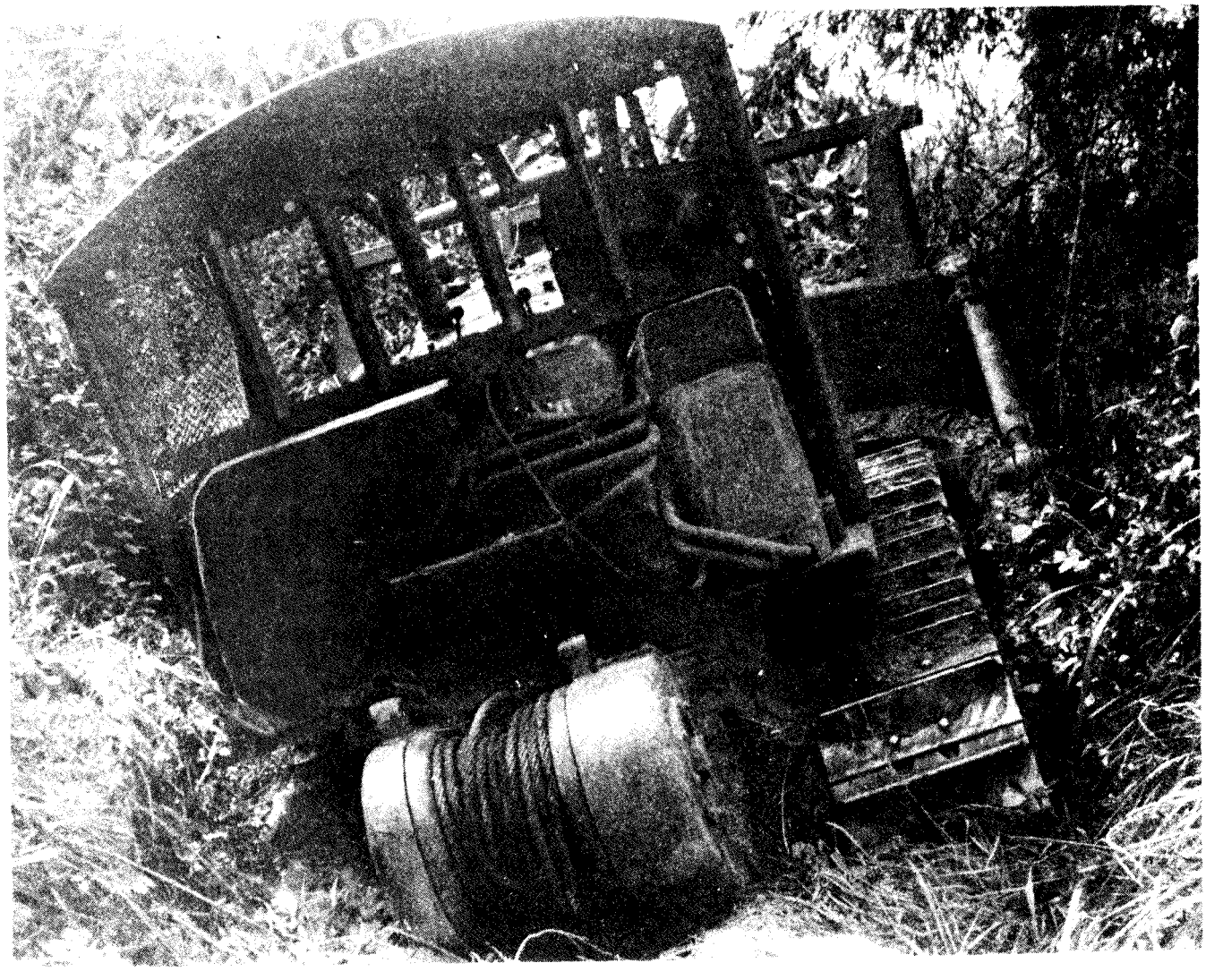


Figure C-1. Land clearing tractor that fell into an underground tunnel.

C-2. Recovery Procedures

a. Track Spinning. Once the tracks start to spin the operator should immediately stop and make an estimate of the situation, which can seldom be accomplished from the operator's seat. Because of the relatively low ground clearance of a tracked tractor

and the ability of the tracks to dig in, spinning the tracks when the tractor is not moving can high center the tractor in one or two revolutions of the tracks. This will increase the recovery problem considerably. By stopping to make an estimate of the situation, the operator can often extricate his own tractor.

b. Winch. The best way to recover the tractor is with its own winch. The winch is most effective when the pull is on the bare drum of the winch as shown in figure C-2, since the leverage is decreased as successive layers of cable are wound on the drum. For this reason it is desirable to unreel all or most of the cable from the winch when it is used to pull heavy loads. Another advantage is gained by using a longer cable, because its natural elasticity or stretch prevents it from breaking as readily under a sudden load. Ideally, the winch cable should be anchored in such a manner that a line drawn through the cable will continue through the centerline of the tractor. If the cable is very far off this line, it will lead to one side of the winch drum, pile up, and become damaged. The cable should not be used with more than 20 deflection from the drum centerline. When no natural anchor is available another suitable vehicle or prepared holdfast must be used to secure the cable.

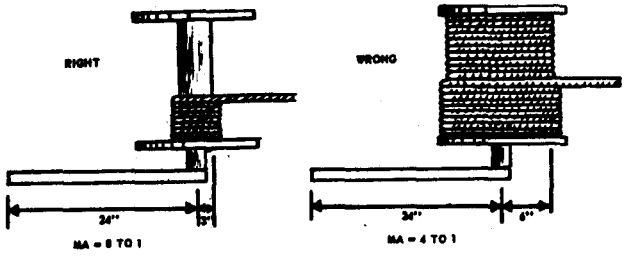


Figure C-2. Right and wrong use of winch.

c. Expedient Recovery. If no other vehicle or natural anchor for the winch cable is available, an expedient method may be used. If the tractor is high centered, a log can be attached to both tracks at one end of the vehicle (fig C-3). If no log is available, a chain or cable can be used. Secure the log, then apply power gradually to both tracks; the log will strike the obstacle and move the vehicle. Care must be taken to remove the log when it reaches the rear or front of the tracks.

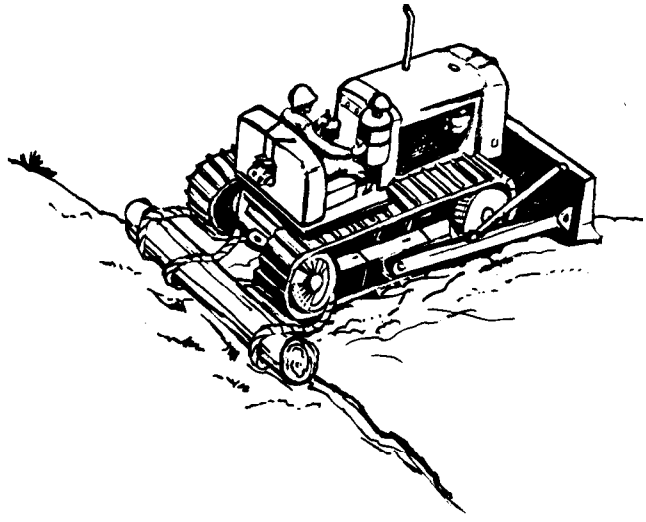


Figure C-3. Log attached to tracks for expedient recovery.

d. Recovery Vehicle. When the tractor cannot free itself, a recovery vehicle is required. In land clearing operations it is preferable that a VTR or other service vehicle with crew be used for recovering the tractor, so that all the other clearing tractors can continue productive work. Perhaps the most common error made in attempting to recover a mired tractor is underestimating the force required. Many cables and chains have been broken trying to jerk the tractor loose using the draw bar pull of another tractor. A tracked tractor has almost twice the pounds pull with a single winch line than it has on the drawbar. Also traction has much less effect on the winch capability. A winch line can be rigged almost as quickly as a chain and even if slight underestimate is made, the winch can still accomplish the recovery. Besides single line pulling, additional blocks can still accomplish the recovery. Besides single line pulling, additional blocks can be installed increasing the mechanical advantage of the winch. Figures C-4, C-5, C-6, and C-7 show several ways to rig a winch line for recovering mired vehicles. TM 5-725 and FM 20-22 show additional rigging and recovery techniques. Winch lines must be attached to the tractor only at those points designed to withstand the load. The drawbar and the pull hook are designed for this purpose. Lifting eyes are designed for vertical loads so should be used with care for horizontal pull. Push arms, track frames, and tilt braces may look solid, but can be severely damaged when heavy loads are applied.

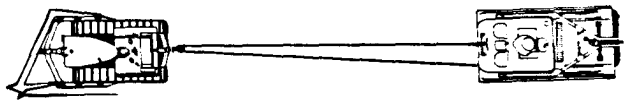


Figure C-4. Recovering mired tractor with recovery vehicle using 2 to 1 mechanical advantage.

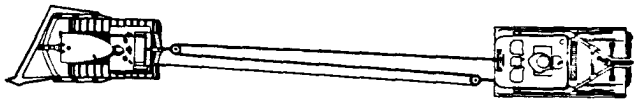


Figure C-5. Recovering mired tractor with recovery vehicle using 3 to 1 mechanical advantage.

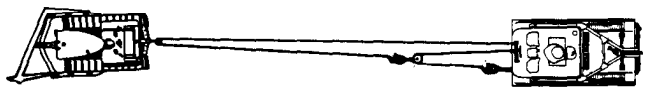


Figure C-6. Recovering with 4 to 1 mechanical advantage rigging.

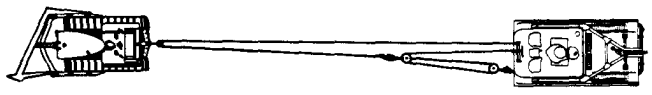


Figure C-7. Recovering with 6 to 1 mechanical advantage rigging.

APPENDIX D

MAINTENANCE OF LAND CLEARING EQUIPMENT

D-1. General

Land clearing, as with any equipment operation, is dependent upon sound maintenance practices and procedures to insure that the equipment is available to accomplish the work. The maintenance posture and capability of a land clearing unit often determine the success or failure of the mission. Command emphasis at all levels is required to insure that adequate time is provided for equipment maintenance and that maintenance activities are organized and supervised just as efficiently as the clearing operation itself. Land clearing provides the most abusive conditions under which a tracked tractor must operate, so without the most carefully planned and stringently enforced maintenance program the deadline rate will soar. There are two essentials to a successful maintenance program during land clearing operations. First, maintenance services must be available in the cut (para 2-9 *b*). A 300-amp welder and an air compressor each mounted in a 6-ton tracked cargo carrier should be stationed in the cut along with maintenance personnel. This saves time in returning the tractors to service during the day. Second, tractors should receive a periodic standdown in the field for complete preventive maintenance services. The recommended frequency is every 10th day of operation. This means that a company will leave three tractors in the night-defensive position each day for this servicing. Where possible, maintenance schedules can be adjusted so that 10-day services are performed on temporarily deadlined tractors. Special care must be taken when selecting the maintenance area in the field so that it will remain firm under continued tractor traffic. In cases of extremely muddy conditions, an AVLB has been launched to use as a maintenance hardstand in the NDP. Corduroy log areas have also been constructed for use as hardstands, because it is impossible to maintain a tractor which is mired almost to its belly pan in mud. In a tactical situation it is often not possible to accomplish maintenance at night in the NDP. Even when night maintenance is possible, it is essential that a minimum of 2 hours per day during daylight be devoted to maintenance of the land clearing tractors and blades. Even more time is required when night maintenance is not possible. After approximately 45 days operation in the field, each land clearing element requires a minimum of 15 days standdown for maintenance which should be conducted at the unit's home base. Special attention must be paid to the supply of repair parts for the equipment. Demand data from previous operations is the best source of information to determine the repair parts required to provide ready availability of high usage repair parts. In addition to a valid prescribed load list (PLL) taken to the field, provisions must be made for aerial resupply of repair parts.

D-2. Chain Saws and Handtools

The maintenance of chain saws and handtools is described in detail in TM 5-461 and the toolroom keeper should have a copy of this TM available. Special attention must be paid to safety procedures which are described in TM 5-461. A sharp tool used properly and safely is the most efficient tool. If chain saws are to be used in a remote area, a chain saw mechanic should be designated and a basic load of repair parts must be taken to the area. In areas where artillery preparatory fires are used extensively, a high rate of chain failure can be anticipated.

D-3. Land Clearing Tractors

The most serious maintenance problem encountered with land clearing tractors is overheating. Because the tractor is almost constantly in motion and debris is continually in the air around the engine compartment, the cooling system is subjected to clogging and damage. The radiator grill guards and the engine side guards will help solve some of these problems, but cleaning the cooling system is still required. When operating under these extreme conditions, the coolant level must be checked often, the radiator should be flushed, and rust inhibitor added to prevent loss of efficiency caused by scaling and rust. When small leaves and sticks are forced against the radiator by the fan, they not only clog the radiator, but they bend the fins, permanently restricting the airflow. An air compressor is used to blow out the debris which is clogging the radiator. Air alone will sometimes not be enough, so a steam cleaner or air and water mixture should be used frequently to thoroughly remove dirt and small particles from the radiator, The belly pans often become full of debris and restrict airflow around the crankcase, also contributing to the overheating problem. This debris should be cleaned out as often as possible or soaked with water to prevent fire. The

remote air intake will reduce the air filter cleaning requirements, but frequent cleaning and inspection of the air filter is still required. Lubrication and other operator and organizational maintenance procedures outlined in the technical manual for the tractor should be followed in detail.

D-4. Land Clearing Blades

The clearing blades, like axes, are used for cutting and must be sharpened or they will become so dull that the tree will be uprooted and not easily sheared off. The blade must be sharpened daily, when clearing in normal conditions, and may require sharpening more often in sandy, abrasive soils or when cutting roots below ground level. A pneumatic, electric, or gasoline portable grinder may be used to sharpen the cutting edge, web, and stinger. When sharpening the cutting edge and web, it is important to maintain the proper shape. Too much angle on the edge limits the shearing action and too small an angle risks having the edge "roll over" or "curl" (fig D-1). The keenness of the point of the stinger is not as important as the sharpness of the cutting edge. The primary concern when sharpening the stinger is that the fillet between the point and the web must be maintained to avoid the possibility of developing crocks. TM 5-3830-236-12 and TM 5-3830-237-12, the operator's and organizational maintenance manuals for the treedozer, Rome K/G blade, describe additional maintenance procedures to be followed when maintaining the blade.

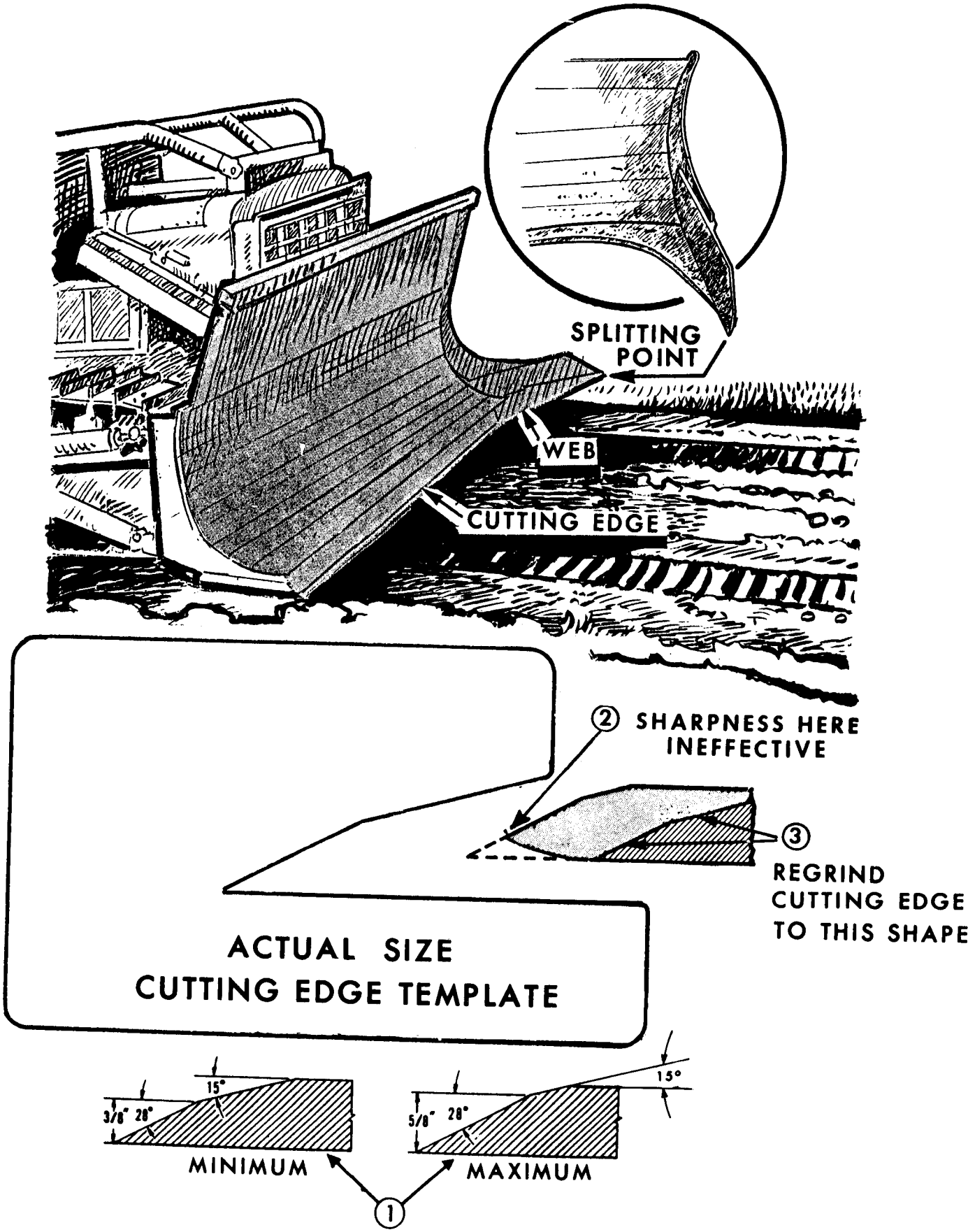


Figure D-1. Cutting edge grinding specifications.

APPENDIX E

CONVERSION TABLES

Length

Metric to English

1 millimeter (mm) = 0.04 inch (0.03937 inch)
1 centimeter (cm) = 0.3937 inch
1 meter (m) = 3.281 feet
l m = 1.094 yards
1 kilometer (km) = 0.621 statute mile
1 km = 0.5396 nautical mile

English to Metric

1 yard = 91.44 centimeters
1 **foot = 30.48 centimeters**
1 inch = 2.54 centimeters

Area

1 sq. centimeter (sq cm or cm^2) = 0.155 sq inch
1 sq meter = 10.76 sq ft
1 sq meter = 1.196 sq yards
1 hectare (ha) = 2.47 acres
1 sq. kilometer = 0.386 sq miles

1 sq inch = 6.45 sq centimeters
1 sq foot = 0.0929 sq meter
1 sq yard = 0.836 sq meter
1 acre = 0.405 hectare
1 sq mile = 2.59 sq kilometers

Capacity or Volume

1 cubic centimeter (cc) = 0.27 fluid dram
1 liter (1) = 1.06 liquid quarts

1 cubic inch = 16.3872 cubic centimeters
1 cubic foot = 0.0283 cubic meter
1 cubic yard = 0.7646 cubic meter
1 fluid ounce = 29.5735 milliliters
1 pint = 0.4732 liter
1 quart = 0.9436 liter
1 gallon = 3.7853

Mass or Weight

1 gram (g or gm) = 0.04 ounce (avdp)
1 kilogram (kg) = 2.20 pounds (avdp)
1 metric ton (Mt or t) = 10000 kilograms
= 2204.62 pounds (avdp)
= 1.10 tons

1 ounce = 28.3495 grams
1 pound (avdp) = 0.4536 kilogram
1 hundredweight (cwt) = 45.3592 kilograms

APPENDIX F

TERRAIN INTELLIGENCE CONSIDERATIONS

Section I. SOURCES OF INFORMATION

F-1. General Information

a. Maps. Maps are a basic source of terrain information. The classification of US maps by type and scale is explained in AR 115-11. Special maps and overlays may be prepared for a specific purpose, or to show only particular characteristics of the terrain. Currently, no maps are being specifically produced for land clearing operations; however, several of the following special maps are available and contain data useful in planning a land clearing operation.

(1) Agricultural (soil) maps are prepared to show the potential of a soil for crop production. Engineering soil maps indicate the \qualities of soil for construction and vehicle cross-country mobility. Agricultural maps have to be interpreted with care to convert them to engineering use.

(2) Geologic maps show the distribution of various kinds of rock formations. Most geologic maps ignore the soils on top of the rock and thus are of limited use in tactical land clearing, except in areas of shallow soil with many outcrops.

(3) Lines-of-communication maps include those that show railway systems, highway route information, navigable waterways, and the routes and stops of airlines.

(4) Relief maps show differences in elevation by the use of various tints and shading patterns. These are valuable in dramatizing areas of steep slopes and rugged topography.

(5) Pictomaps are maps on which the photographic imagery of a standard photomosaic has been converted to interpretable colors and symbols. Natural vegetation and cultural features are ideally portrayal on a pictomap. Because a pictomap is normally more recent than the standard topomap, it is a good source of more current information.

(6) Other special maps show the distribution of major vegetation, water supply sources and distribution systems, cross-country movement, and similar detailed information that can be presented most effectively in graphic form. These special maps are the most useful in planning a land clearing operation, although they are not always available in large scale or for the area of the operation.

b. *Intelligence Reports.* Several Department of Defense intelligence agencies have prepared strategic studies which provide detailed terrain information concerning major geographic areas. The studies of particular interest to the units engaged in land clearing include–

(1) *Terrain studies* contain area intelligence depicted on medium and small-scale maps with accompanying text and graphic material.

(2) *Lines of communication* (LOC) are studies, prepared on either medium-scale maps or single, small-scale foldup sheets, which cent an an analysis of transportation facilities with information on railroads, inland waterways, highways, airfields, pipelines, ports, and beaches.

(3) *Special reports on military geography* are designed primarily for strategic planning and are generally directed toward analysis of a major aspect of military geography such as cross-country movement, amphibious operations, and airborne operations. With the major use of land clearing as a tactical tool, these studies may also be conducted specifically for tactical land clearing. However, the cross-country movement and soil trafficability studies available include many of the factors which can be correlated with land clearing operations.

(4) *Engineer reconnaissance* reports summarize data obtained by reconnaissance, and are a good source of terrain information. They are of particular value in providing current, detailed information about the lines of communicant ions and availability of any natural construction materials.

(5) *Other reports and documents.* Table F-1 is a summary of Army reports which contain terrain information, and are of value in planning a land clearing operation.

Table F-1. Summary of Army Reports Used in Terrain Intelligence

	Report title	Report utilization
1.	Engineer recon report	(1) Preparation of target folders, (2) Preparation of engr recon activity report, (3) Planning and execution of tactical operations, (4) Response to requests for technical data, (5) Planning of logistical support, (6) Preparation of terrain studies and intelligence estimates.
2.	Engineer recon activity report.	(1) Preparation of future collection plans, (2) Planning and supervising engineer recon activity.
3.	Accelerated intelligence reports (spot/flash).	(1) Assessment of the tactical situation and execution of tactical operations, (2) Preparation of intelligence summaries, reports and estimates, (3) Updating of the situation map.
4.	Engineer spot report	(1) Updating of situation map, (2) Preparation and execution of combat operations, (3) Preparation of summary, supplementary, situation reports, (4) Support to requests for combat terrain intelligence, (5) Preparation of intelligence summaries and estimates.
5.	Intelligence summary report (intsum).	(1) Assessment of tactical situation and plans, (2) Preparation of plans for combat operations and logistic planning, (3) Preparation of intelligence estimates.
6.	Engineer intelligence summary report.	(1) Assessment of tactical situation, (2) Preparation of plans for combat operations and logistics planning, (3) Preparation of intelligence estimates.
7.	Engineer supplementary intelligence report.	(1) Assessment of tactical situation, (2) Preparation of plans for combat operations and logistics planning, (3) Preparation of intelligence estimates, (4) Updating situation map (5) Planning, supervising ADM operations.
8.	Special intelligence report	(1) Preparation for and conduct of combat operations, (2) Preparation of plans for recon activity, (3) Support to combat support and services planning.
9.	Front line trace	(1) Assessment of tactical situation, (2) Updating of situation map, (3) Preparation of summary, supplementary intelligence reports, (4) Planning tactical operations, logistical support, and long range rear activity.
10.	Situation report (sitrep)	(1) Assessment of tactical situations, (2) Staff planning of tactical operations, recon activity, and logistic support.
11.	Enginner situation report	(1) Assessment of results of combat support operations, (2) Planning and executing of combat operations, (3) Support to requests for combat terrain intelligence, (4) Updating of situation map, (5) Conduct of ADM operations.
12.	Target folders (demolition).	(1) Updating of situation map, (2) Execution of assigned targets, (3) Support to requests for technical and tactical data, (4) Preparation of demolition reports, (5) Conduct of ADM operations.
13.	Terrain estimates	(1) Preparation of plans for combat and combat support, (2) Planning of engineer recon activity.
14.	Area of operations study (area analysis study).	(1) Preparation of plans for combat operations, (2) Planning of engineer recon activity, (3) Estimates of the situation, (4) Briefing the command staff, (5) Planning logistic support.
15.	Tactical plans and objectives	(1) Planning and executing of combat operations, (2) Planning of engineer recon activity, (3) Briefing the command staff, (4) Preparation of operations orders for subordinate units.
16.	Operations orders	(1) Planning combat operations, (2) Planning recon activities, (3) Support to logistic planning.
17.	Imagery interpretation reports *	(1) Planning combat and support operations, (2) Planning recon activities, (3) Support to requests for terrain intelligence, (4) Analysis of area of operations, (5) Terrain studies.
18.	Area damage assessment report.	(1) Assessment of situation, (2) Planning of repair operations, (3) Preparation of area damage report, and damage assessment, (4) Monitoring of repair and logistic plans.
19.	Enemy minefield report ...	(1) Updating of situation map, (2) Preparation of plans to counteract minefield operations, (3) Preparation of engr. situation and minefield reports, (4) Preparation of target folders (demolition), (5) Support of tactical planning.
20.	Engineer intention to lay minefield report.	(1) Updating of situation map, (2) Preparation of request for supplies and report of intention to lay minefield, (3) Execution of ADM plans, (4) Preparation of target folders, (5) Preparation of barrier trace (6) Monitoring of barrier and denial operations.
21.	Engineer minefield record	(1) Updating of situation map, (2) Preparation of minefield record report, (3) Preparation of target folders, (4) Preparation of barrier trace, (5) Monitoring of barrier and denial operations.
22.	Demolitions report	(1) Coordination of ADM operations, (2) Updating of engineer situation map.
23.	Terrain study on vegetation	(1) Selection of assembly areas and observation posts, (2) Execution of recon patrol activitiy, (3) Planning conduct of movement, maneuver operations, (4) Execution of camouflage operations, (5) Planning of engineer combat operations, (6) Support of artillery planning.
24.	Terrain study on soils	(1) Support to communications planning, (2) Execution of movement, maneuver operations, (3) Planning of combat operation (construction of landing strips, maintenance of culverts), (5) Selection of avenues of approach.

* Also produced by other services.

Table F-1. Summary of Army Reports Used in Terrain Intelligence—Continued

	Report title	Report utilization
25.	Terrain study on rocks	(1) Planning of movement, maneuver operations, (2) Planning of combat operations (construction, maintenance, destruction of roads, bridges, culverts, defensive installations), (3) Selection of avenues of approach.
26.	Terrain study on water resources.	(1) Selection of location of water points and routes to water points, (2) Planning of combat operations (stream crossing bridging), (3) Support to logistics planning.
27.	Terrain study on drainage.	(1) Selection of location of water points and routes to water points, (2) Planning of combat operations (construction of roads, fortifications, fords), (3) Support of river crossings and cross-country movement.
28.	Terrain study on surface configuation.	(1) Support to communications planning, (2) Planning of observation posts and recon activity, (3) Planning of tactical operations and execution of tactical objectives, (4) Planning of barrier and denial operations, (5) Artillery support planning.
29.	Terrain study on state of ground.	(1) Planning for movement, maneuver operations, (2) Planning of ADM activity, (3) Planning of combat operations (construction, maintenance, repair of roads, fords, landing strips, fortifications), (4) Planning of logistics support.
30.	Terrain study on construction suitability.	(1) Planning of combat operations (construction of fortifications landing strips, camouflage, obstacles, CP's, supply installations), (2) Selection of construction supply point locations.
31.	Terrain study on coasts and landing beaches.	(1) Planning of amphibious operations (preparation and removal of obstacles, fortifications), (2) Planning of recon activity, (3) Planning of port construction.
32.	Terrain study on cross-country movement.	(1) Planning and execution of maneuver, movement operations, (2) Planning of logistics support, (3) Planning barrier and denial operations, (4) Planning of engineer combat operations.
33.	Terrain study on lines of communication.	(1) Planning, execution of combat operations (construction, repair, destruction of roads, bridges, railroads, culverts), (2) Selection of ADM placement, (3) Planning of recon activity, (4) Planning of logistics support.
34.	Terrain study on defenses ...	(1) Planning of ADM placement, (2) Planning of recon activity, (3) Planning, execution of tactical objectives and obstacle emplacement or removal, (4) Support to artillery planning.
35.	Terrain study on airborne landing areas.	(1) Planning of area clearing support, (2) Planning of recon activity, (3) Planning of combat operations (construction, repair of landing strips), (4) Selection of helicopter landing zones.
36.	Terrain study on urban areas.	(1) Planning of recon activity, (2) Planning of combat operations (constructions, repair, destruction of fortifications, roads, CP's supply installations), (3) Selection of water points, (4) Planning of logistics support, (5) Transportation planning.

c. Books and Periodicals. Valuable information of use in land clearing may be found in books and periodicals. These include scientific and trade journals, economic atlases, tourist guides, and similar publications. Unpublished records covering meteorological, hydrological, and similar scientific data prepared by Government agencies, engineering firms, manufacturers of land clearing equipment, private societies, and individuals contribute valuable information. Another source is United Nations information on agricultural development potential in forested areas. Extremely valuable data regarding forest vegetation, when desired, may be found in reports prepared by the agricultural, forestry, and conservation agencies of the local government.

d. Other Sources. Captured enemy documents, and interrogation of prisoners of war and refugees, will sometimes give additional up-to-date information valuable in land clearing planning. Enemy maps and terrain studies are especially valuable. Local government agencies, civilian construction contractors, and timber cultivation and harvesting organizations may also be able to provide information.

F-2. Specific Area Information

a. Photographs and Remote-sensor Imagery. Aerial and ground photographs provide an accurate visual record of the terrain and vegetation. They furnish information that is not readily available or immediately apparent by ground reconnaissance, or by visual observation from the air, especially of enemy-held areas. Remote-sensor imagery includes infrared photography and side-looking airborne radar. General information on aerial photography usage is given in FM 21-26 and FM 30-10 and detailed usage is given in TM 30-245, TM 30-245A, and TM 30-246. Properly interpreted, black and white, color, and infrared aerial and ground photography and airborne radar will furnish detailed information on the following:

(1) *Surface configuration.* The physical landforms of the earth's surface can be determined. This includes shape, slopes, forest cover, land-use pattern, and obstacle spacing and height.

(2) *Surface imposition.* General classes of soil (e.g., coarse-grained versus fine-grained) and rock can usually be distinguished.

(3) *Hydrologic geometry.* Both surface and subsurface drainage characteristics can usually be derived from aerial photographs. Infrared color photography is especially useful in determining drainage conditions. Swamps and standing water are readily apparent on color infrared aerial photographs.

(4) *Vegetation.* Typical characteristics of the vegetative cover including general type, density, and uniformity can usually be determined. It is essential that at least some ground reconnaissance information be available if reliable interpretations of forest characteristics are to be obtained, especially in tropical regions.

(5) *Roads and trails.* Well traveled roads and trails can usually be detected and delineated from aerial imagery. However, lightly traveled trails through closed-canopy forests are very difficult to delineate. Color aerial photography will sometimes reveal the presence of trails located beneath the canopy of forests where other types of photography fail.

(6) *Suitability of terrain* for land clearing, construction, and cross-country movement can be determined. Photography and photomaps can be used advantageously in studying areas to determine the feasibility and difficulty of conducting land clearing operations, based on the evaluation of relief, slopes, drainage, soils, and vegetation.

(7) *Limitations.* The amount of information that can be derived from interpretation of photography is limited by adverse weather and dense closed-canopy vegetation on the terrain. It is important in all cases that the information obtained from the aerial photographs be correlated with information from other sources, such as maps, intelligence reports, and personal reconnaissance.

b. Local Populace. In addition to the general information available from local books, periodicals, and Government reports which were previously discussed, much unpublished detailed information is available from inhabitants of the area. Area residents, and lumbering and land clearing contractors, can provide valuable information about previous and current endeavors in lumbering, conservation, and agriculture in their area, which can assist the estimator in determining the required land clearing effort.

c. Reconnaissance. The most direct and accurate method of obtaining specific information about an area to be cleared is to make a personal aerial and/or ground reconnaissance. Aerial reconnaissance by fixed wing or preferably rotary wing aircraft will verify aerial photograph information on the uniformity of the vegetation and point out potential troublesome areas. Through the aerial reconnaissance the areas can be selected for detailed ground reconnaissance. A ground reconnaissance is the best way to verify the photo-interpretation results and it is also the only way specific information on trafficability, soil conditions, and vegetation can be obtained. Thus, ground reconnaissance is almost essential to provide "ground truth" (i.e., the detailed data on which to base photo-interpretation). Before making a personal reconnaissance, all available intelligence sources should be thoroughly researched for pertinent information. At this time voids in area intelligence as well as aspects to be checked should be noted. This reduces the amount of information that has to be obtained through ground reconnaissance, and limits the time required to be spent on the ground in the often hostile area. The detailed information on the terrain and vegetation necessary to plan a land clearing operation is discussed in the following sections of this chapter.

Section II. TERRAIN ANALYSIS

F-3. Weather and Climate

Usually all phases of land clearing from cutting to burning or removal of felled vegetation are concerned to some degree with temperature, humidity, wind, and the amount of rain that falls during a clearing operation. Heavy or prolonged rainfall may result in poor trafficability conditions. In climates of seasonable rainfall, many areas are accessible only during the dry season, and clearing plans should be made to take advantage of the dry season to clear low-lying areas. Rain, high humidities, and absence of wind markedly reduce the drying rates of cut vegetation; thus periods of dry weather, low humidities, and some wind are desireable for preparing vegetation for burning. A small amount of rain during clearing operations may cool the air and put an end to dust and enhance the efficiency of land clearing equipment and personnel.

F-4. Topography

a. Slopes. Slope has a significant effect on most equipment. Medium tractors can operate with little or no loss in production on slopes up to 15 percent

with good soil trafficability conditions. The maximum slope on which a medium tractor can normally operate is 25 percent, but this slope causes a loss in production of up to 50 percent. On slopes steeper than 25 percent or under poor trafficability conditions, the "yo-yo" technique is often the only method possible. In the" yo-yo" method, one tractor goes up and down a steep slope, while being partially supported by the winch cable of another tractor at the top of the slope. This technique is very slow and should be used only when other methods are not possible. The production rate for the "yo-yo" technique is about 10 percent of that on level terrain.

b. Ditches and Streams. Whether wet or dry, streams or drainage ditches delay the land clearing equipment even if the bypasses can be made datively easily. Selected consolidated crossing fords or causeways are essential for multiple tractor operations. The time lost from the cutting operation is a minimum of 5 minutes per ditch or stream crossing per tractor plus the time necessary to construct the crossing.

c. Water Table. Areas with a high water table, such as in swamps or along streams, present special difficulty in land clearing despite otherwise favorable soil conditions. The water table can often be estimated by noting the water level in bomb and artillery shell craters (fig. F-1). Usually, however, a hole must be dug and observed over a period of several minutes (or even hours), and the level to which the water rises in it is noted. Infrared aerial photographs, if available, are often useful, because water strongly absorbs infrared energy, and therefore areas of wet soil (and water) show on such imagery as dark patches.

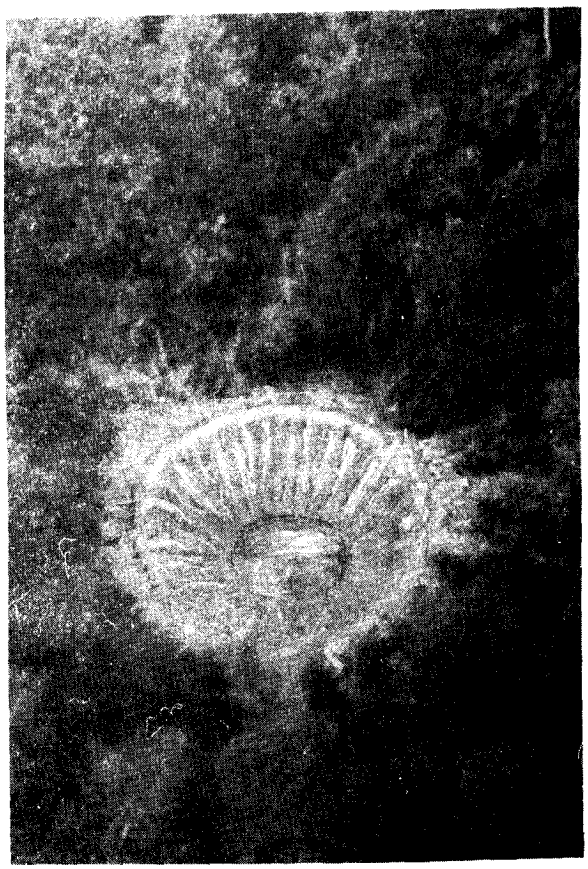


Figure F-1. Water-filled bomb crater.

F-5. Trafficability

a. Soils. Soil characteristics affect land clearing operations chiefly in two ways:

(1) They control the ease with which trees may be uprooted.

(2) They affect soil trafficability (i.e., the ease of movement of men and machines). General trafficability conditions can be crudely estimated by a skilled interpreter who is familiar with the area and who has access to aerial photographs, soils information, and weather data for the several days immediately preceding the time of the operation. It is usually adequate to identify trafficability conditions in the following terms. Good trafficability exists when the vehicle can make almost limitless passes in the same track without significant loss of speed or pulling capacity. *Soft* conditions exist when more than two passes in the same track result in severe impairment of machine performance. *Poor* conditions exist when the first pass is precarious or difficult. *Impassable* conditions exist when the vehicle would be immobilized on the first pass.

b. Rock and Stony Outcrops. If embedded rocks or stony outcropping are present in the area to be cleared, equipment which shears the vegetation at ground level may be severely damaged when the blade or other parts of the machine strike the rocks. In such situations, maintenance is usually costly and time-consuming.

c. Duff. Duff (branches and logs lying on the ground, and stumps) may constitute a significant obstacle to free movement of both men and machines, thus making clearing much more difficult. In addition, the total volume of wood which must be moved may be much greater than anticipated, since the duff can rarely be seen on aerial photographs. Significant amounts of duff are most common in areas of secondary growth where primary growth was not disposed of properly. Large logs and stumps may remain relatively solid in the tropics for periods of 2 to 5 years; in temperate and cold regions the period may be much longer (fig. F-2).



Figure F-2. Duff.

F-6. Manmade Features

a. Road Net. One of the most important factors which must be considered in planning a clearing operation is the adequacy of the access to the area. It is important to insure that adequate access to the area is provided by a road or waterway capable of sustaining the movement of the equipment which is going to be used. However, clearing of distant areas

inaccessible by surface movement may be accomplished with airmobile equipment and teams (chap 2).

b. Structures. Buildings, bunkers, and tunnel complexes are often found in the area to be cleared, especially in a hostile area. If these structures are to be destroyed as a part of the clearing operation, consideration must be given as to what equipment and technique should be used. In many cases the equipment used to clear the vegetation will not be the best choice for use in destroying structures.

c. Airfields and Landing Zones. Due to the weight and bulk of most land clearing equipment, it is normally not airlifted to forward airfields or landing zones. Certain airmobile equipment is used in clearing, but normally these operations are limited in scope and are discussed in detail in chapter 4. An airfield or landing zone is required for support aircraft and airlift of repair parts and supplies to the unit.

d. Obstacles. Intelligence on the presence of friendly or enemy minefield, boobytraps, explosive duds, and other obstacles in areas to be cleared is especially important. Consideration should be given to the use of obstacle reconnaissance and reduction teams to precede land clearing formations.

Section III. VEGETATION ANALYSIS

F-7. Types of Vegetative Cover

The type, density, and distribution of vegetation is controlled by climate, soil type, water supply, and the activities of man. For the purpose of planning lend clearing operations, plants may be grouped into three general types, on the basis of distinctive characteristics requiring separate consideration because of their effect on land clearing operations. These three types are: trees (woody plants more than 3 meters in height); shrubs (woody plants 3 meters or less in height); and herbs and grasses (nonwoody plants of all kinds). Grasses and herbs will not be considered in this manual.

a. Trees. Trees occur in a variety of patterns and associations. Trees tend to occur in four general patterns or distributions: *forests*, in which the trees are irregularly placed and so close together that the crowns touch or intermingle; *woodlands*, in which the trees are irregularly placed but the crowns only occasionally touch; *savannas*, in which the trees are irregulary placed and so widely spaced that the crowns rarely if ever touch); and *orchards* in which the trees are regularly spaced in rows or grids. The term forest is usually reserved for an extensive area; smaller areas may be termed woods, groves, or woodlots. On military maps, any perennial vegetation high enough to conceal troops or thick enough to be a significant obstacle is classified as a forest, woods, or brushwood. Trees are usually classified as needle leaf (such as pines, spruces, and larches) or broadleaf (such as maples, oaks, or figs) and evergreen (i.e., they retain their leaves all year) or deciduous (i. e., they are leafless part of the year). These distinctions are not usually of significance to clearing operations.

b. Shrubs. Shrubs grow in patterns similar to trees. *Shrub* (or scrub) forests are ones in which the plants are irregularly arranged but so closely spaced that the crowns touch or intermingle; *shrub* (or *scrub) savannas* are ones in which the plants are irregularly placed but spaced so far apart that the crowns rarely touch; and *shrub plantations* are ones in which the plants are placed in rows or grids. Shrubs commonly comprise the undergrowth in tree stands of all kinds, but in arid and semiarid regions shrubs like cactus, sagebrush, mesquite, acacia, and euphorbia may be the dominant vegetation.

F-8. Types of Vegetation Structures

Vegetation structures composed of trees and shrubs have been classified in a large number of ways, none of which are usually suitable for purposes of vegetation clearing. Accordingly, a special classification system, specifically adapted to the problems of land clearing, is used as the basis for the discussions which follow.

a. Swamp Forests. These forests grow in situations in which the soil is perennially saturated (or nearly so), and in which there is usually standing water for at least part of the year. Trafficability conditions are generally *poor* to *impassable*. The total variation in height ranges from 10 to 50 meters, stem diameters range from 50 centimeters to 2 meters or more, and the density varies from 10 to 225 stems per hectare. Root systems tend to be relatively shallow, but in many places the bases of the stems are modified into plank buttresses (i.e., Pterocarpus sp.), greatly enlarged bases (e. g., baldcypress), or multiple stems (e.g., Ficus sp.). There is rarely a significant understory or shrub layer. On air photos, these forests may usually be recognized by the datively uniform sizes of the tree crowns, and by their topographic position; they occur only in places subject to persistent flooding. A special variety of swamp forest is the *mangrove forest*, specifically consisting of those species (of Rhizophora and Avicennia) which are characterized by stilt roots (fig F-3). Stilting is widely variable, ranging from a few centimeters to 3 meters high. In extreme cases, the

stilt roots form an almost impenetrable tangle. Since the wood is very tough and resistant, clearing such forests is a major engineering task. On air photos, mangrove forests usually present a remarkable uniform appearance because the individual tree crowns can rarely be distinguished. They grow only in tropical and subtropical regions, and only along coastlines and in estuaries within the range of tidal influence.



Figure F-3. Mangrove forest.

b. Moist Forests. These forests exist where the soil is perennially moist, and may sometimes be inundated and/or saturated for short periods. Trafficability may range from *good* to *poor,* with the usual conditions being *good* to *soft.* Moist forests are usually structurally complex, with trees of many different sizes and species (although exceptions do occur). *Tropical moist forests* are usually characterized in the same stand by stems of widely different sizes, with the trees arranged in "layers" or "stories. " The largest trees (i.e., the first story) may be as much as 80 meters tall. The stem diameters range from 1 to 3 meters, and the density may very from less than one to 10 stems per hectare. The intermediate or "canopy" trees range from 20 to 50 meters tall, with trunks 30 centimeters to 1.5 meters in diameter, and the density ranges from 35 to 400 stems per hectare.. Small second-story and third-story trees also are frequent, ranging in height from 5 to 20 meters, and exhibiting stem diameters ranging from 5 to 25 centimeters and densities ranging from 15 to 900 stems per hectare. Shrub layers are usually sparse and discontinuous. Lianas (woody vines) vary from almost absent to very numerous; where they are numerous, they make it almost impossible to fell a single canopy tree, since its crown will be laced to its neighbors by many lianas. On air photos, tropical moist forests can usually be recognized by the presence of emergents; their very large crowns project in hemispherical masses above the general canopy level (fig F-4 and F-5). *Temperate moist forests* are also exceedingly variable. Many temperate moist forests are "species poor" (i.e., they are dominated by one to several species), in which cases the trees tend to be of roughly the same height and stem diameter. Depending upon site characteristics, species, and climate, the height of such "species poor" stands may range from 10 to about 40 meters (and in extreme cases, nearly 100 meters), stem diameters normally vary from 15 centimeters to 3 meters (and in extreme cases up to about 8 meters), and densities may range from 10 to 225 stems per hectare. In these stands, smaller understory trees are very widely spaced, and the shrub layer is very sparse. However, some temperate moist forests are "species rich" (i.e., are characterized by many species), in which case they tend to strongly resemble tropical moist forests, though they are usually composed of somewhat shorter trees (10 to 40 meters high). On air photos, the "species poor" forest tends to appear as aggregations of crowns of approximately equivalent size and height; the "species rich" varieties exhibit greater variability in crown size and crown height.

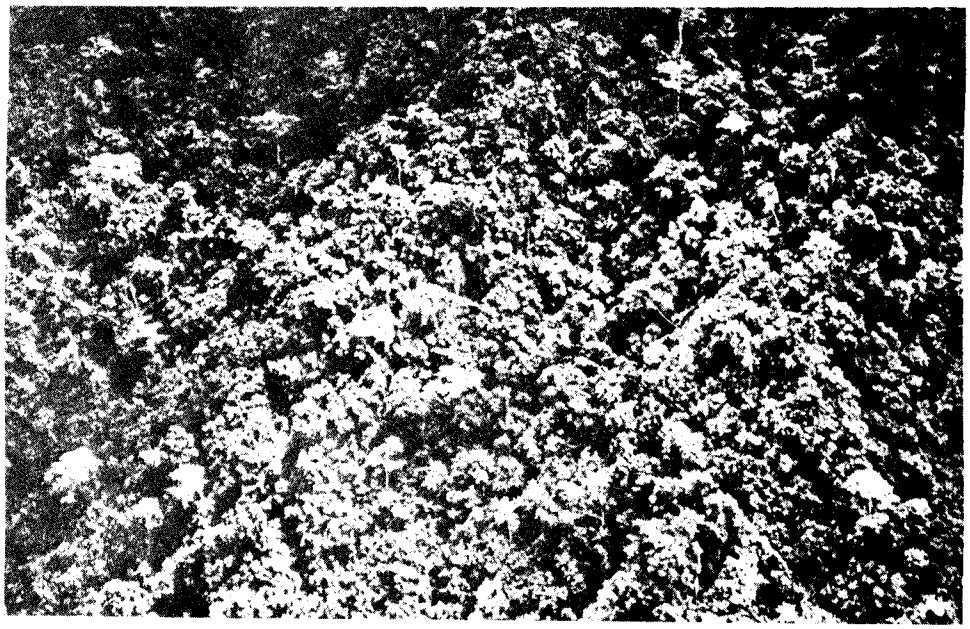


Figure F-4. Tropical moist forest (aerial view).



Figure F-5. Tropical moist forest form ground.

c. Seasonally Dry Forests. These forests (which are often called "monsoon forests" in the tropics) grow in situations in which there is a pronounced water shortage during at least part of the year, even though the soil may be saturated during another season (fig F-6). Trafficability conditions range from good during the dry season to poor or even impassable during the wet season. Seasonally dry forests may also be "species poor" or "species rich". The "species poor" types are generally characterized at one site by relatively uniform sizes and spacings, with heights at different localities ranging from 8 to 25 meters, stem diameters ranging between 10 and 80 centimeters, and densities ranging from 10 to 225 stems per hectare. Smaller understory trees are relatively sparse, and are sometimes thorny. Shrubs may be sparse or even absent. The "species rich" types are characterized at any one site by a wide range of heights and stem diameters. These forests tend to look irregular and unkempt; stem diameters may range from 3 centimeters to 80 centimeters and heights from 5 to 25 meters. The densities of the largest trees may range from 10 to 100 stems per hectare, intermediate tree sizes from four to 900 per hectare, and small trees from 16 to 3600 per hectare. Shrubs are common. On air photos, the "species poor" stands exhibit a relatively regular pattern of crowns of roughly similar size and height. The "species rich" types usually look very ragged and irregular, with a wide variety of crown sizes and marked differences in crown height.



Figure F-6. Aerial view of monsoon forest.

d. Woodlands. These tree stands grow in situations where the lack of moisture occurs over a relatively long period of the year, even though the soil may be saturated for periods of several days intermittently during the dry season. Trafficability conditions are usually good for most of the year, but may become *soft* to *impassable* for moderate periods during the wet season. Woodlands usually consist of only a few species, and thus exhibit remarkable uniformity of size and spacings at any one site. At different localities, stem diameters may range from 10 to 70 centimeters, heights from 7 to 25 meters, and densities may range from four to 36 stems per hectare. Smaller trees are uncommon, and shrubs are

usually sparse to absent. On air photos, these stands are characterized by regularly shaped crowns spaced in such a way that the crowns commonly do not touch, but in which the distance between crowns is rarely more than one-half an average crown diameter.

e. Tree Savannas. These tree stands grow in situations where the moisture shortage is long and very severe, even though the soil may be saturated for brief periods during the short rainy season. Trafficability conditions are uniformly *good* during the long dry season, but may range from *soft* to *impassable* for short periods during the rainy season. The trees tend to be quite uniform in size in any one locality, though they may vary considerably among localities. The total range in height extends from 3 to 100 meters, stem diameters range from 8 to 50 centimeters, and the density may range from 16 stems per hectare to one stem per 3 or 4 hectares. Shrubs are sparse. Both trees and shrubs are commonly thorny. On air photos, these stands may be readily recognized by the wide spacing of the trees (fig F-7).



Figure F-7. Typical tree savanna.

f. Shrub Forests. These vegetation stands usually occur in regions in which the climates are similar to those which produce tree savannas. The reasons for the occurrences of shrub forests in some localities and savannas in others is not certainly known, but there is some indication that shrub forests are more common on slopes (especially with sandy or stony soils), whereas tree savannas are more common on flat surfaces with clay soils. Trafficability is uniformly *good* during the dry season, but may range from *good* to *poor* for short periods during the wet season. Shrub forests tend to be quite irregular, with significant variations of plant size and mean spacing occuring within a few tens of meters. Shrub heights range from 1.5 to 3 meters, stem diameters range from 1 to 5 centimeters (many shrubs exhibit multiple stems), and densities range from 300 to as many as 14,000 plants per hectare. In most of the stands, many of the shrubs are thorny. The root systems are commonly deep and extensive. On air photos, their stands can usually be recognized by the extreme irregularity of crown sizes and crown heights, and by their "patchiness" (i.e., marked changes in texture within short distances).

g. Shrub Savannas. These stands usually occur in regions characterized by extreme aridity, with rain falling only rarely and erratically. Trafficability is almost uniformly *good.* Shrub heights range from 1 to 3 meters, stem diameters range from 1 to 5 centimeters (many shrubs exhibit multiple stems), and densities range from one to 400 plants per hectare. Root systems are usually widespread and very deep. In some localities a large proportion of the plants are thorny. Shrub savannas are common on

arid plains and mountains, with the densest concentrations of plants along washes and other situations where soil moisture tends to collect or persist. On air photos, these stands may be readily recognized by the isolation and low stature of the individual plants.

h. Tree Orchards and Plantations. These stands may occur in almost any climatic area, but each climatic region is normally restricted to a relatively few species. Trafficability conditons may be extremely variable, depending upon the climatic region; in continuously wet climates, traffic ability may range from *soft* to *poor* or *impassable;* in climates having dry seasons, trafficability is normally *good* to *soft* during the dry season. The trees in these stands are normally (but not invariably) arranged in rows or on a grid. In any one locality the trees tend to be very similar in size, but there may be a good deal of variation among localities. Trees may range in height from 4 to 30 meters, stem diameters range from 10 to 40 centimeters, and mean density from 10 to 400 per hectare. These stands are usually kept free of shrubs and lianas, but (especially in the tropics) poorly tended orchards or plantations rapidly develop very dense stands (3,000 to 40,000 stems per hectare) of small trees (stem diameters 1 to 3 centimeters, heights 3 to 6 meters) or shrubs. Tree plantations and orchards can usually be readily recognized on aerial photographs by the row or grid arrangement of the tree crowns (fig F-8).

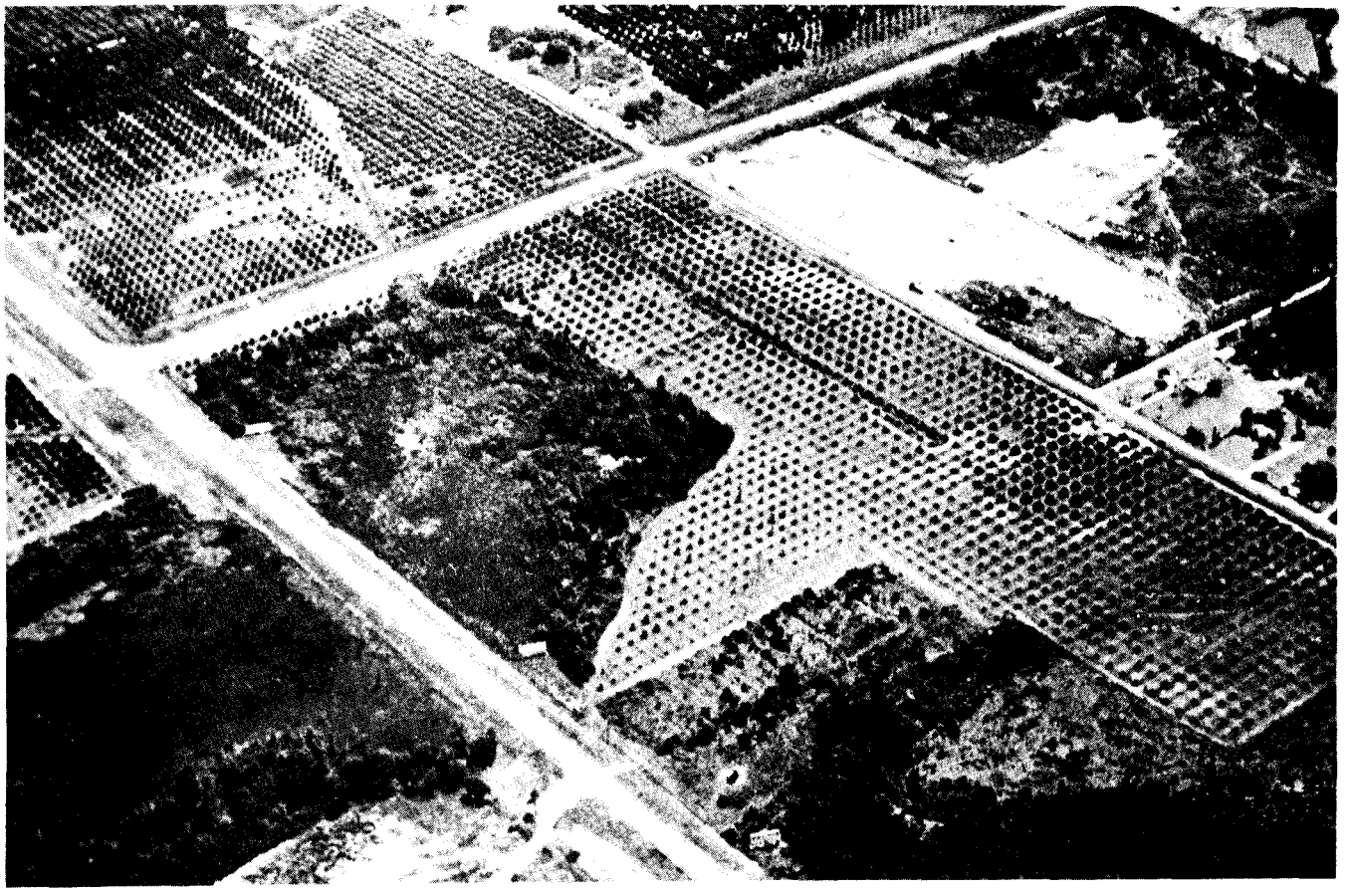


Figure F-8. Citrus orchards.

i. Shrub Orchards and Plantations. These stands may occur in either temperate or tropic climates, but they are especially common in the tropics, where coffee, cacao, and tea are grown. Trafficability may be quite variable, depending upon the climatic area *(h* above). The shrubs in these stands are often arranged in rows or grids, but this practice is by no means as common as in tree plantations and orchards. In addition, shade trees are commonly planted more or less randomly among the shrubs. The shade trees vary in height from 5 to 20 meters, in stem diameter from 5 to 35 centimeters, and in density from complete absence to as many as 36C stems per hectare. The shrubs, which commonly are characterized by multiple stems, range in height from 1 to 3 meters, in stem diameter from 1 to 15 centimeters, and the density may range from 350 to 3,000 plants per hectare. These stands are readily

identified on air photos if the shrubs are planted in a regular pattern but if the planting is irregular, and if the shade trees are numerous, the general appearance is one of a very ragged and unkempt low forest resembling shrub forest, as described in *f* above.

F-9. Objective Analysis of Vegetation

The descriptions of the types of forests and other vegetation outlined in paragraphs F-7 and F-8 are those commonly used in intelligence reports and are valuable as far as they go. However, specific quantitative descriptions of the vegetation on the site to be cleared are required.

a. Tree Count. All of these variables must be determined by "tree count." Methods of tree counting vary (TM 5-342), depending upon the extent of the area to be cleared. In small areas a 100 percent count is made, but in larger areas several representative samples are selected and counted and the result is then applied to the whole area. Normally a "tree count" is made by measuring a straight line at least 100 meters long or 363 feet long (fig F-9). The actual tree count is made by three men, one recorder walking along the line and two counters, one on each side of the line. Each counter measures the number and diameter of all the trees on his side on the line to a lateral distance of 5 meters, metric system, or 15 feet, English system. As the counters progress along the line, they call out to the recorder the vegetation they encounter and he records it in the following categories:

Less than 12 inches diameter (undergrowth)
12 to 24 inches diameter
24 to 36 inches diameter
36 to 48 inches diameter
48 to 72 inches diameter
Over 72 inches diameter

As trees are counted, they are measured. The diameter is found by measuring the trees at 4 ½ feet (1.22 meters) (A, fig F-10) above the ground. If a buttress (B, fig F-10) is present, it should be noted and the measurement is then made at the top of the buttress (C, fig F-10) where the trunk begins to run straight and true.

The tree count should be made two, or preferably three, times for each distinct type of vegetation in the area. The number of trees of each size per unit area may then be estimated from the averages obtained in the tree count sample.

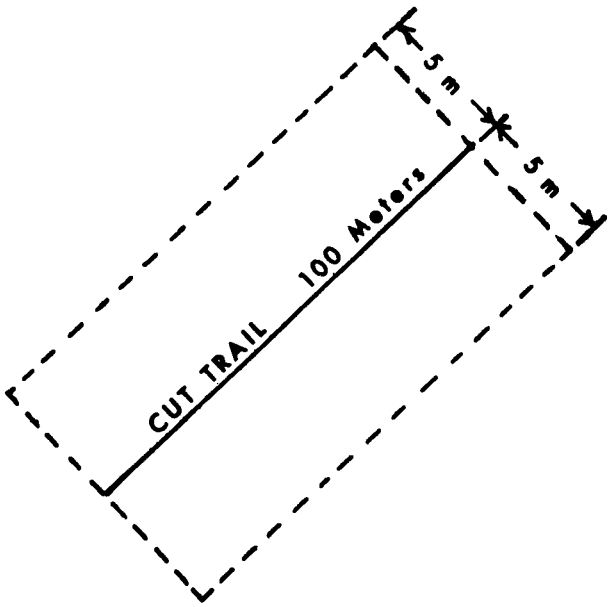


Fig. A

METRIC SYSTEM

To convert to hectares multiply results from plot "A" by ten.

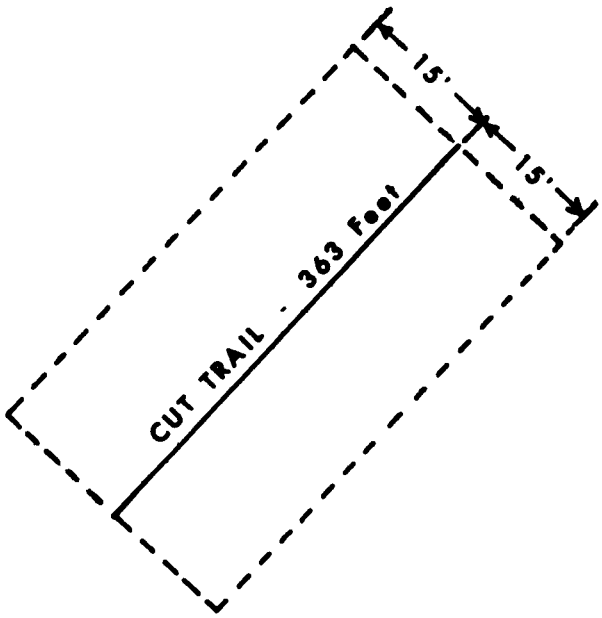


Fig. B

ENGLISH SYSTEM

To convert to acres multiply results from plot "B" by four.

Figure F-9. Tree count plots.

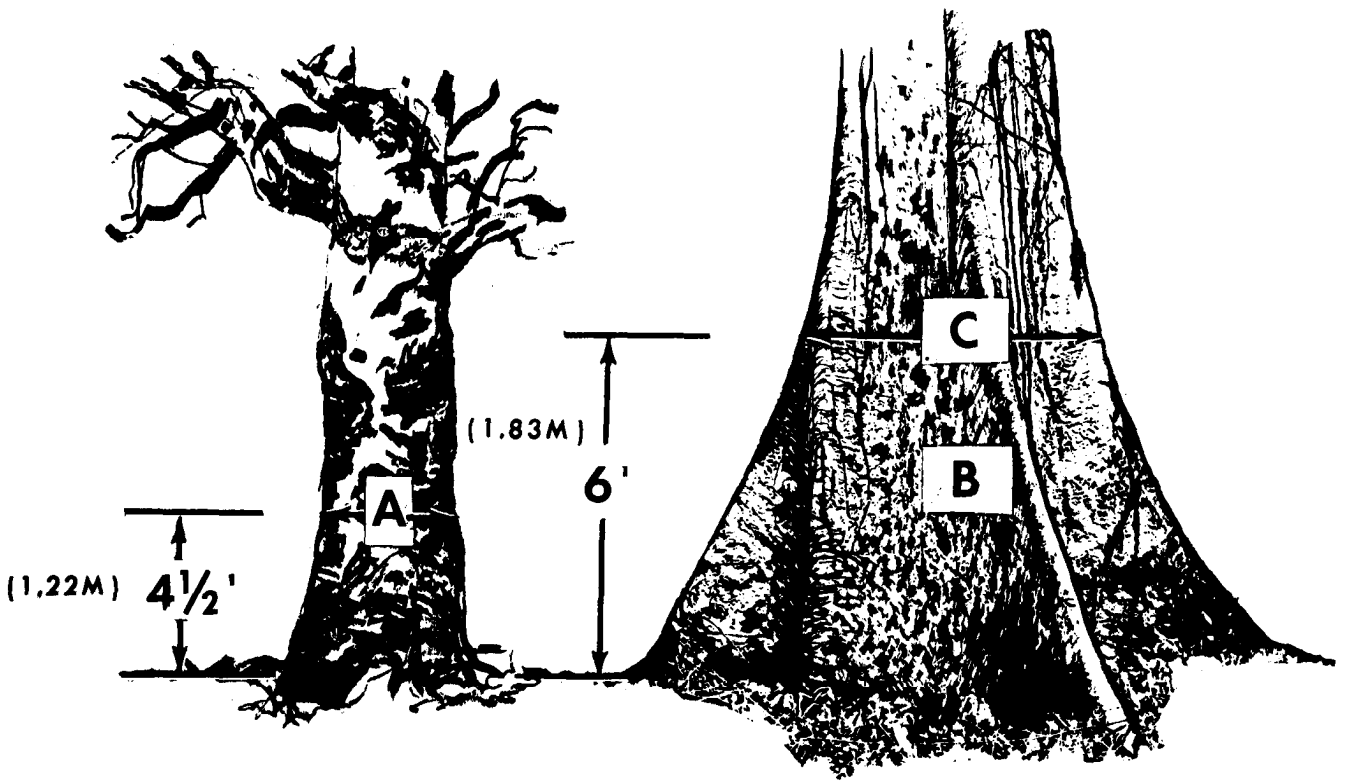


Figure F-10. Normal and buttress root trees.

b. Wood Density and Undergrowth. The wood density (hard or softwood) and root system (tap or lateral roots), plus a description of any undergrowth or vines should be determined. The wood density is more easily obtained by striking the tree with an axe or machete and recording the result. For the sake of standardization, undergrowth, vegetation under 12 inches in diameter, can be described as —

Dense–unable to see a man standing 20 feet (6.1 meters) away.

Semidense-barely able to see a man standing 20 feet (6.1 meters) away.

Sparse– able to clearly see a man standing 20 feet (6.1 meters) away.

Notations should also be made of the presence of high climbing vines which bind the treetops together and which would complicate the felling operations. There are more detailed methods of analyzing vegetative cover than that described above which can be found in any good forestry textbook, but these methods are normally more complex than required for most land clearing estimates. The greater the amount of care that is taken in selecting the representative samples, the more accurate will be the results of the analysis. Areas containing extensive undergrowth adjacent to roads, rivers, and clearings should be avoided in sampling unless they form a significant part of the area to be cleared.

c. Secondary Growth. The above technique applies principally to virgin forests and to older secondary growth. In young secondary growth, less than 20 years, additional factors become significant. These include the amount of partly decayed vegetation on the forest floor, the number and soundness of fallen trees, logs, and stumps, and the number of stems in the following diameter categories:

Less than 3 inches diameter
3 to 6 inches diameter
6 to 12 inches diameter

An actual count of these sizes may not be feasible in many cases, but a percentage estimate of each size is required to make a complete analysis of the secondary growth.

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