



Production Estimation I



Production Estimation

for Logging Machines

- Machine time
- Productivity
- Time study methods

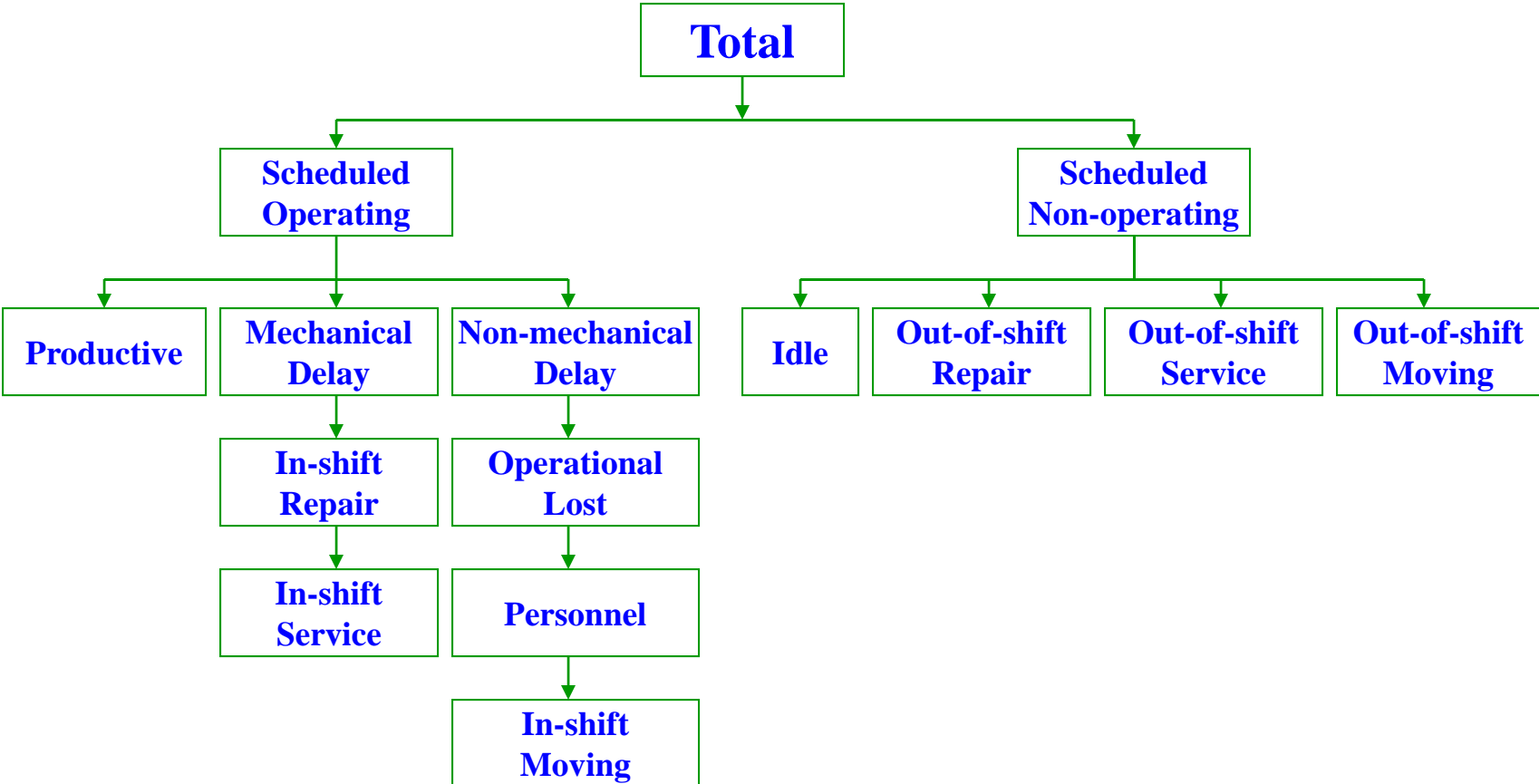


Machine Time

- Machine time can be broken into a variety of distinct categories:
 - Scheduled Operating
 - Scheduled Non-operating



Machine Time





Useful Concepts

of Machine Time

- Scheduled machine hours (SMH),
- Productive machine hours (PMH),
- Mechanical availability (%MA), and
- Utilization (%UT).



Scheduled Machine Hours

- Scheduled machine hours include all time the machine is scheduled to work.
- For instance, if a logger planned to work from 6 AM to 4 PM with 30 minutes for lunch, his skidder or feller-buncher would have 9.5 SMH per day.

$$\text{SMH} = 10 - 0.5 = 9.5 \text{ hours}$$



Productive Machine Hours

- Productive machine hours represent the time during which the machine actually performs work.
- This excludes time lost to both mechanical and non-mechanical delays.



Productive Machine Hours

- **PMH = SMH – Mechanical Delays – Non-mechanical Delays**



Productive Machine Hours

- If the skidder in the above example spent:
 - 45 minutes waiting for trees to be felled,
 - 20 minutes replacing a hydraulic fitting, and
 - 10 minutes moving to another landing,

- Its PMH would be:

$$\text{PMH} = 9.5 - (0.75) - (0.17) - (0.33) = 8.25 \text{ hours}$$



Mechanical Availability

- Mechanical availability represents the percentage of scheduled time in which the machine is mechanically able to perform work.

$$MA = \frac{SMH - \text{Mechanical Delays}}{SMH} \times 100$$



Mechanical Availability

- Lower MA indicates:
 - a lack of maintenance,
 - abuse by an operator, and
 - need for machine overhaul or replacement, or other needed actions.



Utilization

- Utilization measures the percentage of scheduled time that the machine is actually productive.

$$UT = \frac{PMH}{SMH} \times 100$$



Utilization

- Lower level of UT for a machine can indicate:
 - an out-of-balance system or
 - low level of availability.
- Utilization \leq Mechanical Availability
 - If zero time lost to non-mechanical delays, UT could equal MA.
 - However, it can never exceed MA.



Utilization

- **$UT \leq MA$ is important to be remembered.**
 - It concisely expresses an important principle in operating a piece of equipment efficiently.
 - Efficient operations and minimum operating costs depend upon achieving a high degree of utilization with a machine.
 - High levels of MA are prerequisite for obtaining high utilization levels.

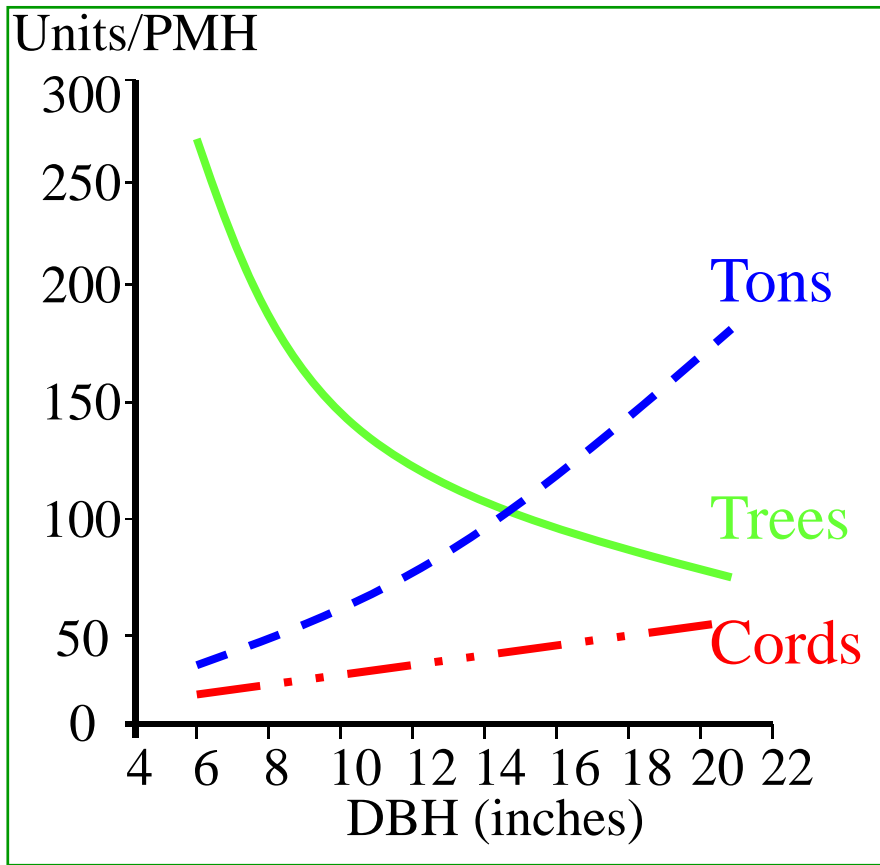


Machine Productivity

- Is defined as production per unit time.
- Production of logging systems is normally measured:
 - in units of volume (cords, tons, cubic feet, MBF) or
 - in terms of number of stems
- Common productivity measures include:
 - volume/PMH, volume/SMH,
 - stems/SMH, stems/PMH.



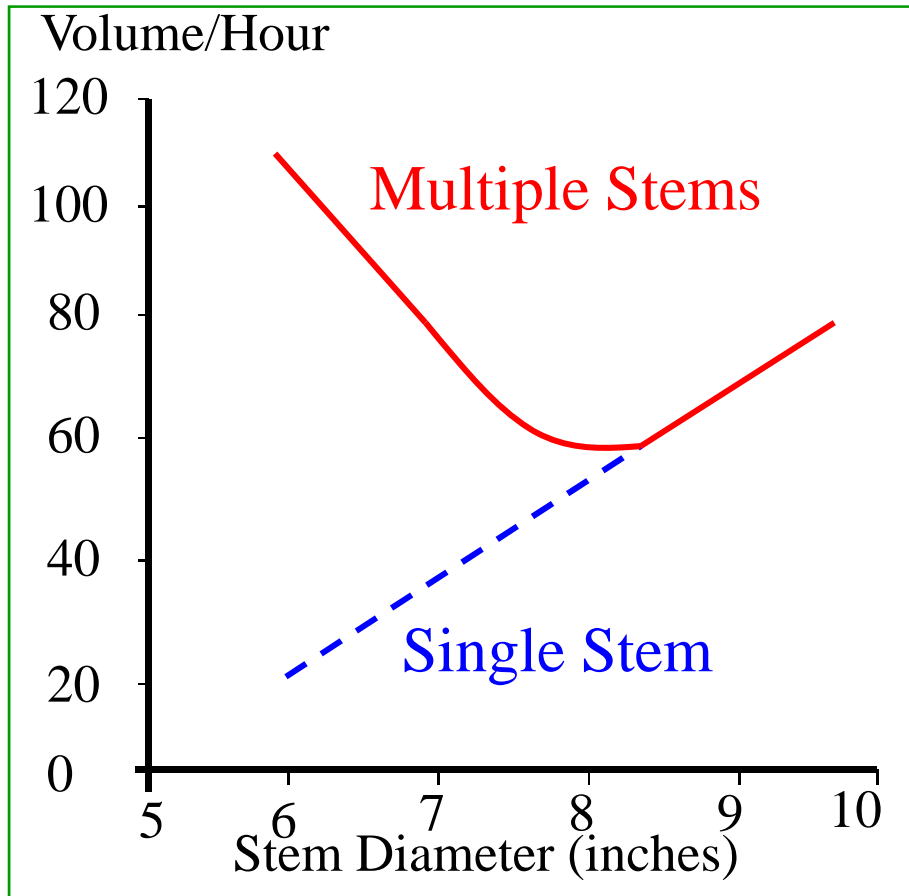
Productivity



- ◆ Productivity measured in stems per unit time usually **decreases with stem size**.
- ◆ Productivity measured in volume per unit time usually **increases substantially with increases in stem size**.



Productivity



- ◆ To compensate for the effect of small volumes as stem size is reduced:
 - handling multiple stems in smaller timber to maintain acceptable levels of productivity.
 - used effectively in the mechanized timber harvesting.



Time Study Methods

- Time studies are used to determine the potential productivity of a logging machine.
- There are three general types of time studies:
 - Gross time study
 - Work sampling
 - Elemental time study
- We often combine more than one of the above techniques when conducting any individual study.



Gross Time Studies

- Are “quick and dirty” ways to get some general ideas about what a machine can do.
- These studies often:
 - examine a short time period and /or
 - lack any statistical design, thus
 - provide results with limited use.
- Tell us what happened, but very little about why it happened.



Gross Time Studies

Example: measuring productivity of a grapple skidder

- Using a stopwatch or our wristwatch:
 - We begin timing when the skidder leaves the landing to the woods for another load of logs. We end after the skidder returns to the landing and drops the logs.
 - On its second departure to the woods, we record the elapsed time as **6.56 minutes**.
 - We also measured the logs skidded as **0.64 cords**.



Gross Time Studies

Example

- Productivity = $0.64 \text{ Cords}/6.56/60$
= 5.85 cords/PMH



Gross Time Studies

Example

- In reality, we should record several skidder turns, computing a mean and variability.
- Even with repeated observations and simple statistics, this method offers relatively little information.
- For instance,
 - How is the time spent after leaving landing?
 - What percentage of time is spent on traveling, grabbing loads, and so on?



Work Sampling

- A statistically based procedure
- Observations of a logging machine are taken at random times
 - At each observation the current activity of the machine is recorded (e.g. functions).
 - The percentage of time for each activity is determined by:
 - dividing the number of observations for each activity by the total number of observations



Work Sampling

- Can provide a good estimate of the percentage of time for each activity.
- Does not measure the amount of time spent on each activity.



Work Sampling Example

- ◆ Assume that **175 observations** are taken at random over an **eight hour shift** for a cable skidder.

Activity	Obs	% of total time
Travel Empty	51	29%
Choking Logs	18	10%
Travel Loaded	52	30%
Unchoking Logs	12	7%
Deck Maintenance	9	5%
Mechanical Delays	11	6%
Non-mechanical Delays	22	13%
TOTAL	175	100%



Work Sampling

- An excellent method for identifying the MA and UT.
- In the example, **MA=94%, UT=81%.**

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Work Sampling

- Productivity cannot be measured since times are not recorded.
- Either gross time studies or work sampling should be combined with elemental time studies to estimate the productivity.



Work Sampling

- Assume that the following data were collected for the above example:
 - Skidding cycles during 8-hr shift: **52**
 - Total volume skidded: **30.2 cords**
- Productive machine hours = $0.81 * 8$
= **6.48 PMH**
- Productivity = $30.2 / 6.48 = 4.66$ cords/PMH