Logging System Analysis
Harvesting Function and System

- Function is the subdivision in a harvesting system, for example:
  - Felling
  - Skidding or forwarding
  - Loading
  - …

- Functions are combined together to form a harvesting system.
Elemental Functions of Chainsaw

- Walk to tree
- Acquiring
- Felling
- Delimbing and topping
Elemental Functions of Feller-buncher

- Move to tree
- Cut
- Move to dump
- Dumping
Elemental Functions of Cable Skidder

- Travel empty
- Choke load
- Travel loaded
- Unchoke load
Elemental Functions of Grapple Skidder

- Move to load
- Grapple load
- Move during loading
- Travel loaded
- Delimbing using a gate
- Ungrapple
Elemental Functions of Harvester

- Move to tree
- Boom extend/retreat
- Cut
- Swing boom
- Processing
Elemental Functions of Forwarder

- Move to load
- Load
- Move during loading
- Travel loaded
- Unload
Logging Systems

Three common systems could be combined as:

- Chainsaw felling + cable skidder
- Feller-buncher + grapple skidder
- Harvester + forwarder
Harvesting Functions
(Skidder Systems)

- Chainsaw and Cable skidder
  - Fell
  - Delimb and top
  - Skid
  - Load and haul

- Feller-buncher and grapple skidder
  - Fell and bunch,
  - Skid and delimb,
  - Load and Haul
There may be multiple machines performing a single function such as:

- two skidders pulling behind one feller-buncher
- a single loader serving four tractor trailers
Each function has inherent productivity under the given conditions. This is to say,

- a machine taken by itself will have no restraints from its sister functions
- it will produce wood at some rate plus or minus its inherent variability
Limiting Functions

- Machines don’t produce at the same rate:
  - Some are more productive than others
  - Some have higher utilization than others

- For example,
  - Feller-bunchers fell more trees per day than manual chainsaw operators.
  - A skidder may not be able to skid all the wood produced by a feller-buncher within the same period of time.
What is a Limiting Function?

- In the FB + SD system,
  - If the feller-buncher produces wood twice as fast as the grapple skidder can skid, at some point the feller-buncher must quit work.

- For a trucking operation,
  - If four trucks are needed to haul the wood produced and you only have one truck, the in-woods part of the crew will have to slow down.

- Under these situations,
  - skidding and hauling are apparently the least productive functions of the logging systems that are called the limiting functions.
Why Balancing Harvesting System?

- Minimizing costs per unit
- Maximizing profits
- Maximizing production
What is System Balancing?

- To mesh functions together effectively to form systems, each function must produce wood at about the same rate.
- The process of making each function in a system produce equally is called system balancing.
Balancing the System

- Four ways to balance an operation:
  - Add or subtract machines
  - Work some functions more or less scheduled hours
  - Change work conditions
  - Change machines
System Balancing
(Example)

For example, say we have a feller-buncher feeding a grapple skidder.

<table>
<thead>
<tr>
<th></th>
<th>FB</th>
<th>15.07 cords/PMH</th>
<th>MA=70%</th>
<th>10.55 cords/SMH</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>7.36 cords/PMH</td>
<td>MA=75%</td>
<td>5.52 cords/SMH</td>
<td></td>
</tr>
</tbody>
</table>

• The system productivity is that of the least productive function,
  • the skidding is controlling the system
  • the feller-buncher is restricted to 5.52/15.07=0.37 or 37% UT
• If addition of another skidder,
  • the skidding productivity is (2*5.52=11.04 cords/SMH)
  • it brings the system up to near optimum production (10.55Cords/SMH).
Utilization of a Function

\[
UT = \frac{\text{System Rate} (\text{cords} / \text{SMH})}{\text{Machine Production Rate} (\text{cords} / \text{PMH}) \times (\# \text{ of Machines})}
\]
Balancing a feller-buncher and skidder system:

**Feller-buncher:**
- productivity: 15.07 cords/PMH
- MA: 70%
- total fixed cost: $15.91/SMH
- total variable cost: $19.14/PMH
- labor cost: $7.00/SMH plus 30% fringe

**Skidder:**
- productivity: 7.36 cords/PMH
- MA: 75%
- total fixed cost: $15.57/SMH
- total variable cost: $17.79/PMH
- labor cost: $7.00/SMH plus 30% fringe