Annual Temperate Forest Tree Mortality Protocol

# **Sites:** Smithsonian Ecological Research Center (SERC), Smithsonian Conservation Biology Institute (SCBI), Harvard Forest (HARV), Wind River Forest (WFDP), Ordway-Swisher Biological Station (OSBS)

**Methods:**

*General*

Locate the corners of the quadrat. Locate and evaluate all trees within the quadrat and make sure you check all trees before moving to the next quadrat. Coordinates (x, y) are given in reference to the quadrat size that is used at each ForestGEO plot.

*Tree classification*

Find the trees’ tag on the datasheet or electronic data form. Mark tree is as either **“A”** (alive), **“AU”** (alive unhealthy), **“DS”** (dead standing), **“DG”** (dead ground), or **“DN”** (dead not found).

**Notes**:

Sometimes a tree recorded dead in a previous year is “back to life”. If a dead tree is alive in the current census (meaning you are 100 % sure it is alive), mark the tree as A and you must make a **note** in comments that you double checked the status.

If the status is **“A”**

1. Mark status
2. Record crown position.
3. Record **percentage of crown** still intact (%).
4. Record **percentage of crown** living
5. Record lean angle and direction if leaning

If the status is “**AU**”

**AU** is used for trees that are alive but noticeably unhealthy (e.g., fallen and uprooted but not yet dead; wounded, insect damage). Every tree coded **AU** needs at least one FAD.

1. Record FADs in order of importance (at least 1 factor)- See FAD codes below.
2. Record crown position.
3. Record **percentage of crown** still intact (%).
4. Record **percentage of crown** living
5. Record lean angle and direction (if leaning)
6. Record Liana load if there are lianas.
7. Record wound, canker, or rot categories (if applicable)
8. **Take pictures:** Take a picture of alive unhealthy tree if picture appropriately captures FAD. For example, take picture of wounds to main bole if they are category 2 or 3 (large or massive damage), but not of leaf damage high in canopy. Take a picture of up to three pics of main FADS. Make nice close-ups if any insect, insect galleries or fungal fruiting body are found.

If the status is **“DS”** OR **“DG”** & previously “**A”**:

1. Record FADs in order of importance (at least 1 factor)- See FAD codes below.
2. Record crown position.
3. Record **Percentage of crown** still intact (%).
4. Record lean angle and direction (if leaning)
5. Record Liana load if there are lianas.
6. Record wound, canker, or rot categories (if applicable)
7. **Take pictures:** Take a picture of dead tree if picture appropriately captures FAD. For example, take picture of wounds to main bole. Take up to three pics of main FADS. Make nice close-ups if any insect, insect galleries, or fungal bodies are found.

If the status is **“DS”** & previously “**DS”**:

1. Mark status
2. Record crown position.
3. Record **percentage of crown** still intact (%).
4. Record **percentage of crown** living

--record this information for remote sensing/crown delineation purposes

If the status is **“DG”** & previously “**DS**”

Record status and continue.

--Additional Fields--

***Lean angle (%)***

If tree is still rooted and is leaning, estimate the angle of lean in degrees from vertical. This angle is measured in degrees from the base through the point of measurement or POM (Figure 2).

***Lean angle (degrees)***

If the tree is leaning, take a compass bearing in the direction of the lean from the base of the tree.

***Liana load (levels: 0 – 4)***

0 = lianas absent

1 = up to 25% of the tree crown covered by lianas

2 = 26–50% liana cover

3 = 51–75% liana cover

4 = 76–100% liana cover.

***Wounded main axis (levels: 1 = small, 2 = large, 3 = massive)***

1 = small damage, smaller in area than a square of DBH × DBH in shape.

2 = large damage, greater in area than a square of DBH × DBH in shape.

3 = massive damage, affecting >50% of the basal area (i.e., a very deep and extensive wound; Figure 4) or >50% of the living length. These are cases of main stem breakage in which the breakage is not complete, and the broken part is still connected and alive, and trunks that have been longitudinally split in two.

***Canker, swelling, deformity (levels: 1 = small, 2 = large, 3 = massive)***

1 = small deformity area, smaller in area than a square of DBH × DBH in shape.

2 = big deformity, greater in area than a square of DBH × DBH in shape.

3 = massive deformity or canker, greater than >50% of the basal area or >50% of the main axis length.

***Rotting trunk (levels: 1 = small, 2 = large, 3 = massive)***

1 = small rotting area, smaller in area than a square of DBH × DBH in shape.

2 = big rotting area, greater in area than a square of DBH × DBH in shape.

3 = massive rotting, affecting >50% of the basal area or >50% of the main axis length.

*Comments and other status indicators*

For tree conditions or agents of mortality not specifically defined below, record diagnosis in the notes or comments section of the form.

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| --- | --- |
| **FAD Categories:**  **U**= Unable to determine cause of death or unhealthiness (or something specific not listed)  *Mechanical damage*  **B** = Broken stem (note cause, indicate level on tree)  **CR** = Crushed by other tree or tree parts  **UP** = Uprooted tree (root bole exposed)  **S** = Slope failure (evident landslide even if small)  **L** = Lightning (tree splitting, straight scars from above)  **Fi** = Fire (stem charred, fire scars on bark) | *Biological agents*  **AN** = Animal damage (specify animal if possible)  **BB** =Bark beetles present, beetle galleries  **I =** Insect infection (e.g., EAB, other)  **DF** = Complete defoliation (record crown condition using Smith/Flower method below 1-5 scale)  **F** = Fungi visible (give names if known)  **H =** hollow stem  **K** = Canker or swelling present  **LF** = Leaf damage (look for leaf spots, blotch, etc.)  **W** =Wound  **R** = Rotting stem  **R1** = Root damage  **R2** = Armillaria root disease |

Notes on *leaf damage* and *complete defoliation*.

* Code if damage ≥ 20% of the foliage (or branches) with ≥ 50% of the leaf/needle affected
* General symptoms of *defoliation* and *leaf damage* include large amounts of missing foliage, browning foliage, extensive branch mortality, or dead tree tops.

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**Figure 1. Crown illumination (taken from Arellano et al., 2020)**

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**Figure 2. Lean angle (Taken from Arellano et al., 2020)**

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**Figure 3. Crown assessment (taken from Arellano et al., 2020).**

**Top left is 100% crown intact and 100% crown living, top right—100% intact and 90% living, middle left—90% intact and 70% living, middle right—90% intact and 50% living, bottom left—70% intact and 30% living, bottom right—40% intact and 0% living**

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**Figure 4. Schematic of wound size (taken from Arellano et al., 2020)**

A picture containing text, screenshot

Description automatically generated

**Examples of FAD (wounds, rot, cankers):**

Level-1

A tree trunk in the woods

Description automatically generated with low confidenceA close up of a tree

Description automatically generated with medium confidence A tree trunk with a heart carved in it

Description automatically generated with medium confidence

**Left:** level 1 wound, **middle:** level 1 wound, level 1 rot, fungi visible. **Right:** level 1 canker/swelling

A picture containing tree, outdoor, jungle, trunk

Description automatically generatedLevel-2

A tree with a hole in it

Description automatically generated with medium confidenceA picture containing outdoor, plant, tree, bark

Description automatically generated

**Left:** level 2 rotting stem, level 2 wound, level 2 canker. **Middle:** Level 2 rotting stem, level 1 wound. **Right:** Level 2 canker/swelling

Level-3

A tree with a hole in it

Description automatically generated with medium confidenceA tree with a hole in it

Description automatically generated with low confidence

A picture containing outdoor, trunk, plant, jungle

Description automatically generated

**Left:** level 3 wound, level 3 rotting stem. **middle:** level 3 canker, hollow stem, level 2 wound. **Right:** level 3 wound, level 3 rot, hollow stem.