Tree Failures Evaluation Using Survey123

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INTRODUCTION

The *Tree Failure Form* is for collecting information on tree failures to simplify evaluation of tree failure patterns. A tree failure is the physical breakage of the tree's trunk, one or more branches, or one or more roots. Tree failures in outdoor recreation sites may result in property damage or personal injury. While evaluating trees based on defects allow for predictions of potential future failures, documenting why trees fail in an area will provide information regarding specific failure tendencies. This can enhance our understanding of the importance of structural defects, common site disturbances in areas, and weather events associated with failures. The goal of this form is to provide improved hazard tree evaluation methods and enhanced management.

Some benefits of this *Tree Failure Form* include:

- Manages data in the cloud with instant accessibility and password protection.
- Simplifies data sharing.
- Provides a tracking system for an area's failure history.
- Highlights problems and sites that need attention.
- Assists in identifying weather and seasonal trends.
- Defines common failure types and associated indicators/defects.
- Provides failure data by tree species to build species profiles.
- Identifies which tree species are prone to fail.
- Improves the selection of tree species suitable or not suitable for a site.
- Promotes better tree management.

A tree failure system, called the California Tree Failure Report Program (CTFRP), was developed by the University of California in 1987 and was well received by arborists. Due to the success of the CTFRP, the USDA Forest Service in cooperation with the International Society of Arboriculture (ISA), developed the *International Tree Failure Database* (ITFD) designed for worldwide application. The objective was to analyze data and generate reports to improve the understanding and detection of tree hazards prior to failure. However, the ITFD went offline in 2015 due to a lapse in funding. There has been an ongoing attempt to restore it since 2018. At the time of this publication the ITFD is still offline.

The *Tree Failure Form* is based on the ITFD. The hope is, if the ITFD returns, data will be compatible and can be easily imported into the ITFD. Data generated by the *Tree Failure Form* is 100% compatible with previous ITFD data. This form was designed for forest campgrounds, picnic sites, and other developed sites in national forests. Although the same standard data is collected, fields that do not apply to national forests or are not seen in a forest setting were removed to simplify data entry. This manual defines the data fields to ensure data is collected and recorded as intended.

SURVEY123 AND ArcGIS

The *TreeFailureForm_*** is an electronic form for the inspection of trees in developed forest sites that can be run on any smartphone, tablet, or computer using the App or computer program *Survey123* by ESRI. A "paper" or PDF version of this form can be downloaded from the Rocky Mountain Region's (Region 2's) Hazard Tree Management home page: http://www.fs.usda.gov/goto/r2/fh/hazard. More information regarding the use of the form is provided during the Rocky Mountain Region's *Hazard Tree Management* training class: http://www.fs.usda.gov/goto/r2/fh/training. The "***" in *TreeFailureForm_*** represents a three-letter abbreviation for each R2 National Forest.

This *Survey123* App is a simple form-centric application for collecting hazard tree survey data online or offline. A survey is composed of two items in ArcGIS Online (AGOL). One is the form item, which represents the questions and settings in your survey. Another is the feature service item, which stores the survey data. Please keep in mind that both items are required for the survey to function. The following steps should be performed to successfully complete tree failure assessments.

- **Obtain an AGOL account** - USDA Forest Service employees can request a Forest Service AGOL account by clicking on this link and filling in the information: https://apps.fs.usda.gov/gtac-tools/AGOL/request_access.php. Others can obtain an account by following the instructions on this website: https://www.arcgis.com/home/signin.html.
- **Download the Survey123 App or access the online application** - Users can download the free App for phones and tablets at iTunes or Google Play (**Figure 1**) or https://www.esri.com/en-us/arcgis/products/survey123/resources (**Figure 2**).

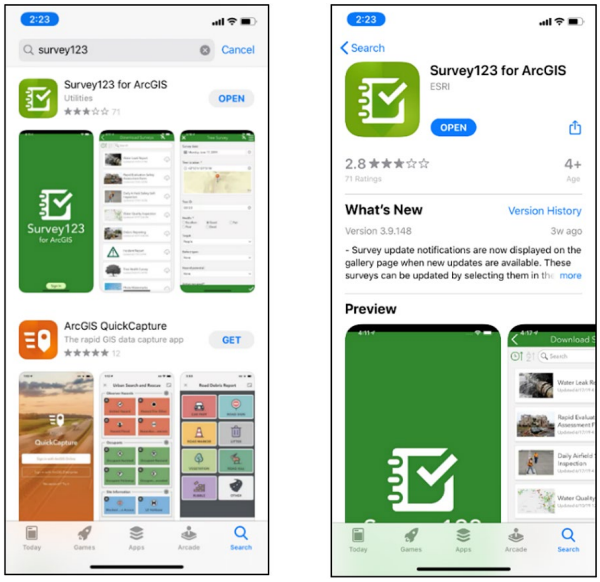

Figure 1. Download *Survey123* App via Store on phone or by downloading *Survey123* desktop app.

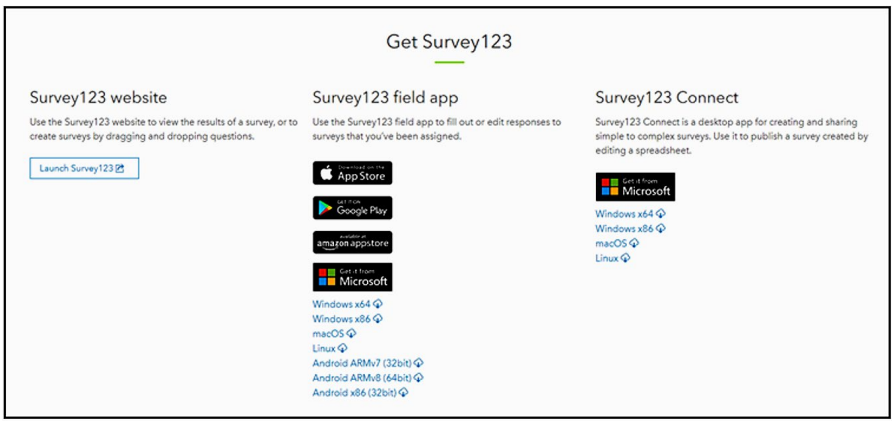

Figure 2. Online access to *Survey123* website, field App, and Connect desktop program.

- **Request to be Added to a R2 Hazard Tree Group** - Each R2 National Forest has an AGOL hazard tree group. To request access to a Forest R2 hazard tree group, contact your group owner to be added to the group. Group owner information is located on the R2 Hazard Tree Management Website. Users must belong to a group in order to use the Hazard Tree Evaluation e-form.

  Group member – Members of a *R2 Hazard Tree* Forest group should only include people who collect data for the Forest and/or use/manage the data. They should be people who work on the Forest where the data is being collected, and they should understand the data being collected/managed. The tasks of group members are to collect data according to R2's *Hazard Tree Management* Technical Report R2-73, and/or manage the data. All group members should attend *R2 Hazard Tree Management* training to understand the proper methods.

  Group owner/manager – Owners and managers should work on the Forest and be able to work with all district group members (ideally someone in the Supervisor's Office). They should understand AGOL enough to manage the data. Preferably owners and managers should attend *R2 Hazard Tree Management* training to understand the data and data fields. The main duties of group owners and group managers are to add or remove group members and ensure data is backed up to the T: drive. The preferred method of backing up collected data is to export the feature layer to a file geodatabase in AGOL and then download the geodatabase to the T: drive. They can help manage the data and assist group members with questions.

- **Download the appropriate Tree Failure form to your device** - There is one form for each R2 National Forest. Once you belong to a R2 Hazard Tree group, the survey form is available for download. Open the *Survey123* App, sign in using your AGOL username and password, click on the dropdown menu in the upper right corner, select "Download Surveys," then click on "*TreeFailureForm_****" (**Figure 3**). Along with the three-letter abbreviation for each R2 National Forest there is also a "*TreeFailureForm_Training*" form. The "Training" form can be used to practice using

the form. It is OK to add test data to the "Training" form. The "Training" form data is shared among all R2 National Forests and will be deleted at least once a year. The R2 National Forest forms should be used for real tree failure data; those forms should NOT be used to test the Tree Failure Form.

- **Start collecting data** - Following *Survey123* installation and downloading the form, when you open the *Survey123* App, you will see the "My Surveys" page. You can start collecting data by clicking on "*TreeFailureForm_****" icon.
- **Submitting report** - Reports can be submitted directly from the *e*-form or can be entered from the paper form into a phone or computer using *Survey123*. Once submitted, data can be modified or copied to assist in entry of other trees.

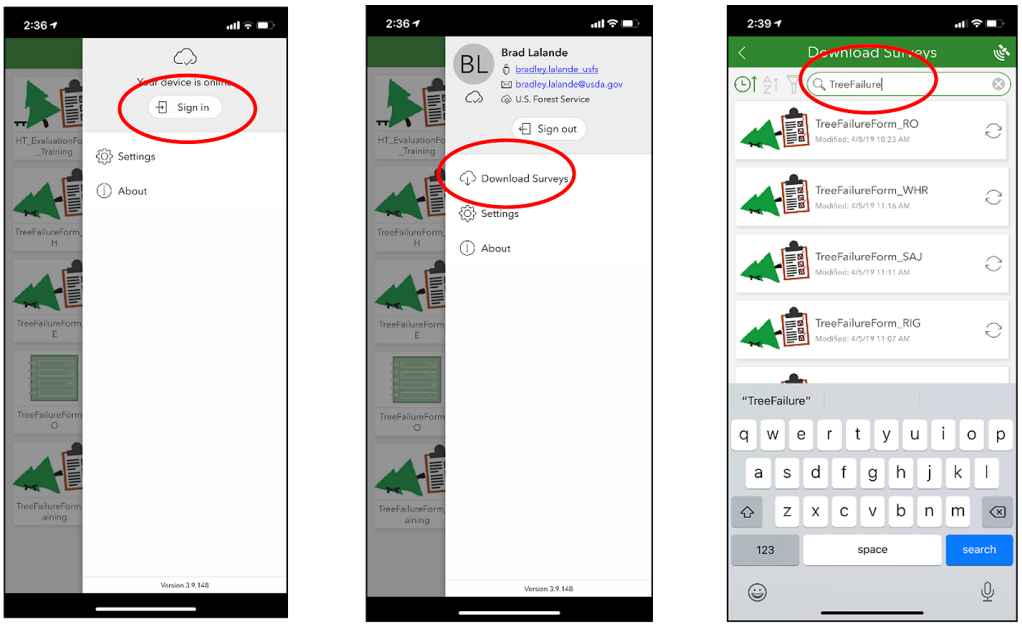

Figure 3. Before collecting data, log into your AGOL account using the three horizontal bars in upper right corner. After logging in, select upper right figure indicating your account (circle with your initials). Then choose "Download Surveys" to find R2 survey forms. Search "TreeFailureForm" to locate your specific forest and download relevant forest's *Tree Failure Form*.

Entering Data

To start collecting data, click on the "*TreeFailureForm_****" icon then click the "Collect" bar on the bottom of the screen (**Figure 4**). The form is set up in the same order as the paper form except "GPS point" and options for photographs are included in the *e*-form. Fields with an asterisk (*) are required.

Collecting GPS Coordinates

The first variable you will see on your screen is "Tree Location." A GPS coordinate for each survey (*i.e.,* tree) will automatically be generated if you have the device's GPS signal turned on (you can also fine-tune the point by pressing on the map image and dragging the pin to the appropriate location). *Survey123* will average your location until

5 m or better accuracy is achieved (**Figure 4**) or you save the survey. Alternatively, you can digitize your location on-the-fly by pressing on “Press to capture location using a map,” then navigating the pinpoint to the tree’s location on the map. You must have a GPS signal to do this. Background imagery can be changed by selecting the top dropdown menu icon on the right (**Figure 4**) and then selecting the preferred background. When you are satisfied with your location using either method, click on the check mark (√).

Survey results are stored in a spatial database, so every survey (*i.e.,* tree) must have a location. If your device does not report its location or you do not digitize it on-the-fly (*i.e.,* you do not have location service), a default location is used (lat. 0, long. 0 which is a point in the Atlantic Ocean west of Africa). If you do not have GPS, azimuth and distance from a reference point can be used to stem-map surveyed trees.

Offline maps can be added to phones/tablets for use in *Survey123* when Wi-Fi and data service is not available. Tile packages have been created for each Ranger District in the region. Maps can be accessed either through AGOL (click on the “Content” tab on the top of the screen, then click on “My Organization,” and type “FSTopo tile packages, *YOUR* ranger district” in the search line, or by downloading them from the Forest Service’s T: drive: T:\FS\Reference\GeoTool\agency\TilePackages\R02.

Maps can also be created with ArcMap or using Tile Package Kreator.

- **ArcMap** - https://desktop.arcgis.com/en/arcmap/latest/map/working-with-arcmap/how-to-create-a-tile-package.htm
- **Tile Package Kreator** - https://geonet.esri.com/groups/survey123/blog/2017/01/31/taking-your-maps-offline-with-tile-package-creator

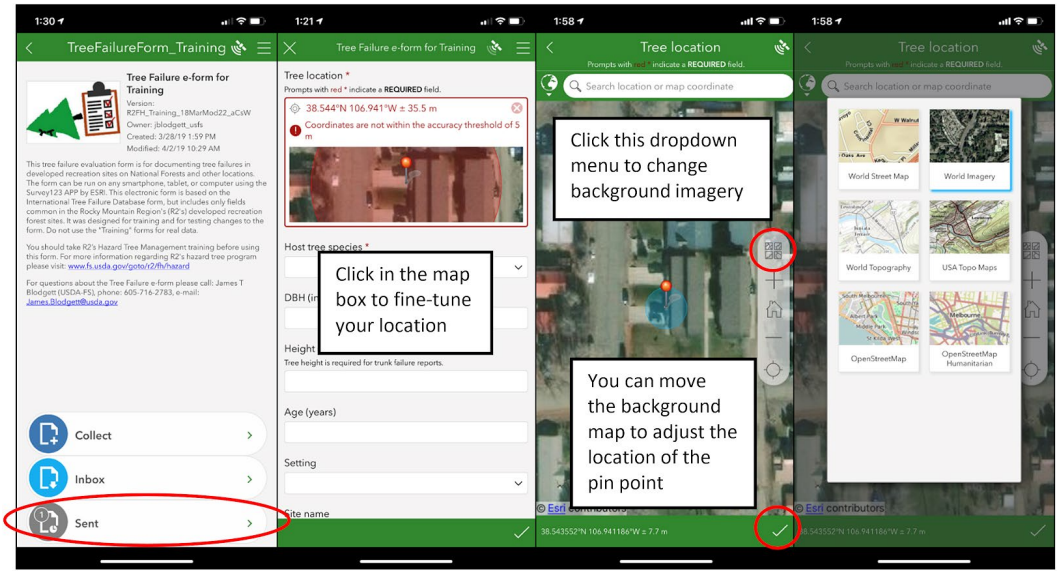

Figure 4. To begin entering data click “Collect” tab. Then proceed through all steps to submit a *Tree Failure Form*. Coordinates are auto-generated if the device’s location service is turned on. Otherwise, a point can be fine-tuned, or generated on-the-fly by manually adjusting the location of the pinpoint.

Inputting Tree Failure Data

Fields on the *e*-form with a red asterisk (*) are required (*e.g.*, Host tree species, DBH, etc.). The report will be rejected if required fields are not entered. Fields that are not marked with a red-asterisk will enhance the tree failure evaluation. Data consists of drop-down menus (*e.g.*, Host tree species, Setting, etc.) and manual entries (*e.g.*, DBH, Height, Age, Site name, etc.; **Figure 5**). Drop-down menus with circles indicate a single selection, whereas those with squares indicate multiple selections can be made.

- **Failure types: (Trunk Failure/Branch Failure/Root Failure)** - This section answers the question: What part of the tree failed? Categorize the failure as a trunk, branch, or root failure (**Figure 6**). Upon making a selection, you will be prompted to answer questions specific to that failure type.
- **Additional information** - This section applies to all failure types (**Figure 7**).
- **Collecting photos** - The *Survey123* App allows you to include photos of defects, trees, or other pertinent features (**Figure 8**). Photos can be captured using the camera on your device (select the camera icon by scrolling to the bottom of the form) or they can be uploaded (select the file folder icon and navigate to the location where the photo is stored).

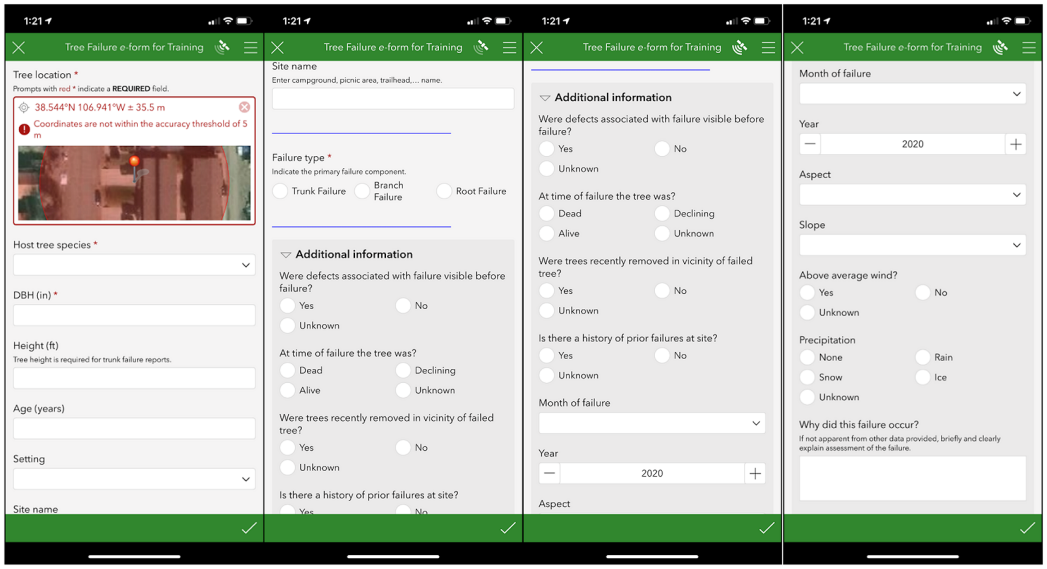

Figure 5. After collecting GPS data, input initial tree data to characterize the tree failure. Images depict data fields/questions.

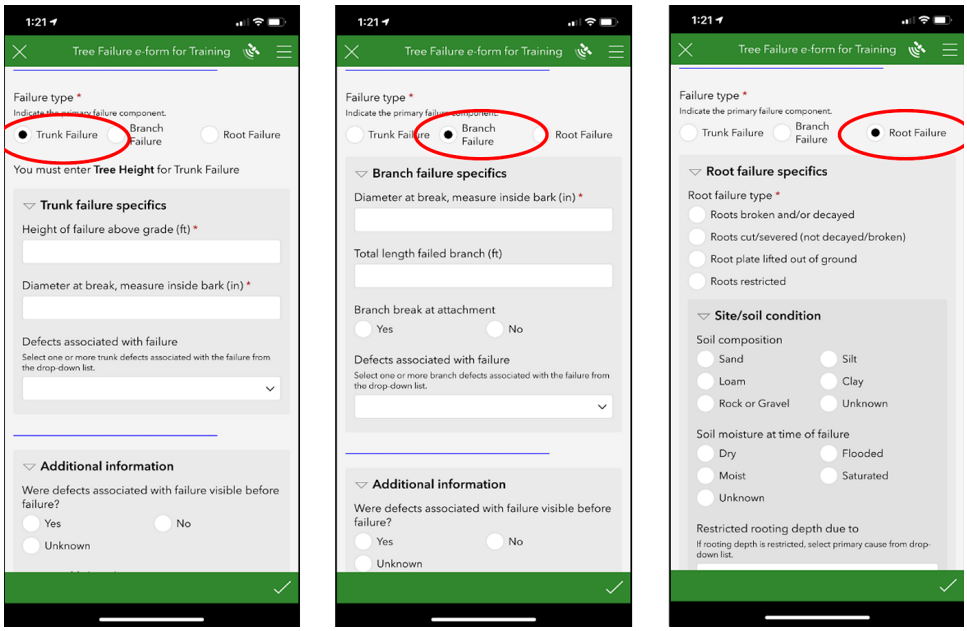

Figure 6. Select the primary failure type: Trunk, Branch, or Root. Each type has different questions.

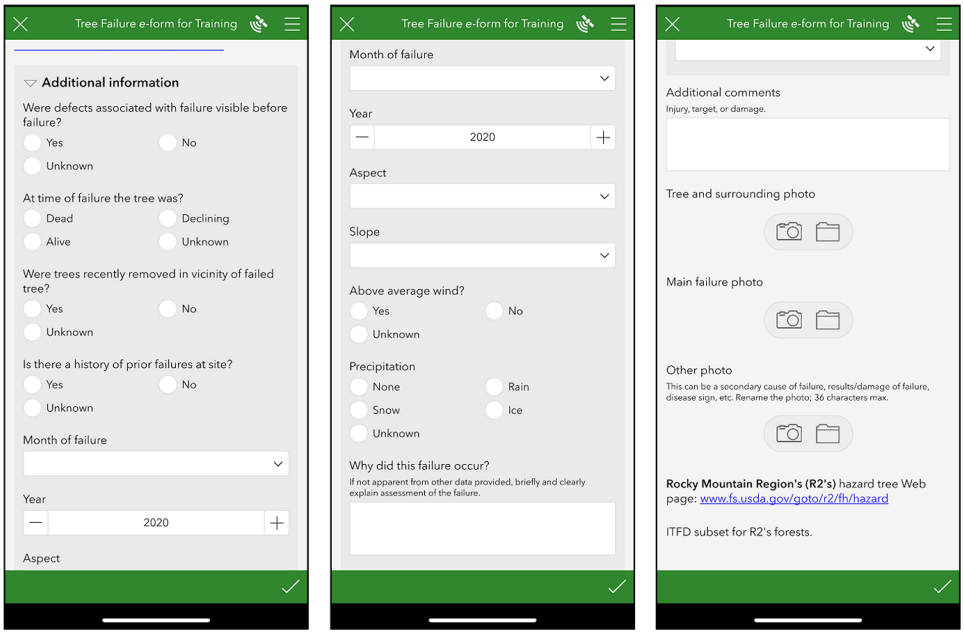

Figure 7. Input additional relevant information to assist failure assessment.

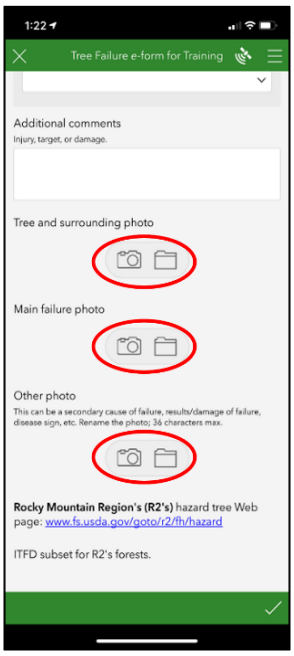

Figure 8. Collect photos using the device's camera or by uploading from a file.

Saving Data

Once all data has been entered, there are three options on the bottom right of the screen: “Send now,” “Continue this survey,” or “Save this survey in the Outbox” (**Figure 9**). You must be online to click “Send now” which stores the record in the cloud. If you are offline, click “Save this survey in the Outbox” and the data is stored in the app for later submission. You can click on “Outbox” once you are online, then click “Send surveys” at the bottom of the screen to save all your surveys to the cloud. “Continue this survey” directs you back to the current survey.

Once a survey is sent it can still be edited on your device. Click “Sent” on the main page and then click on the survey you want to edit (**Figure 10**).

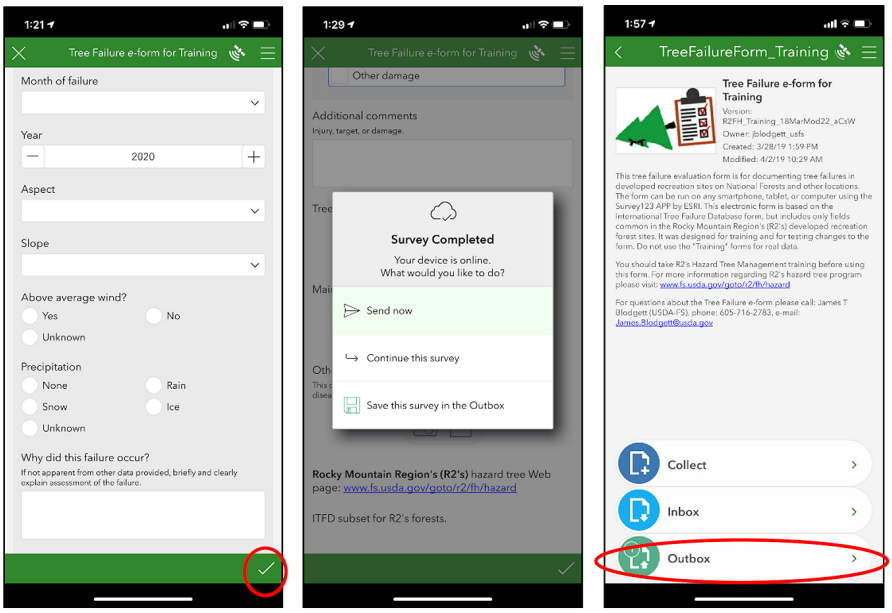

Figure 9. Save data by clicking the check mark in bottom right of screen. Three options will display to Send now, Continue, or Save data. If data is saved in the "Outbox," you should submit the survey(s) when online.

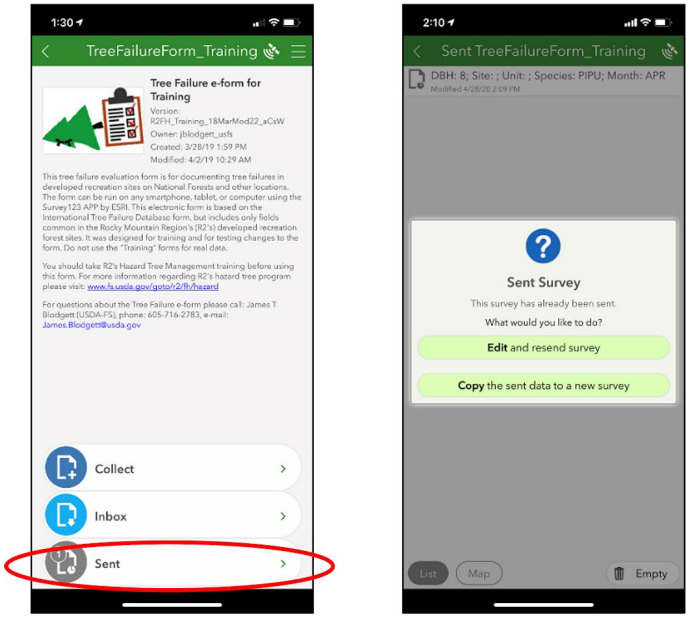

Figure 10. Sent surveys can be edited on your device and re-sent.

Downloading Data

Open *Survey123* online (https://survey123.arcgis.com): sign into your AGOL account. If you don't see your form, type "*TreeFailureForm_****" in the search box in the upper right corner (**Figure 11**). Click on the data tab (little gray box with horizontal lines below *TreeFailureForm_****) for the appropriate form.

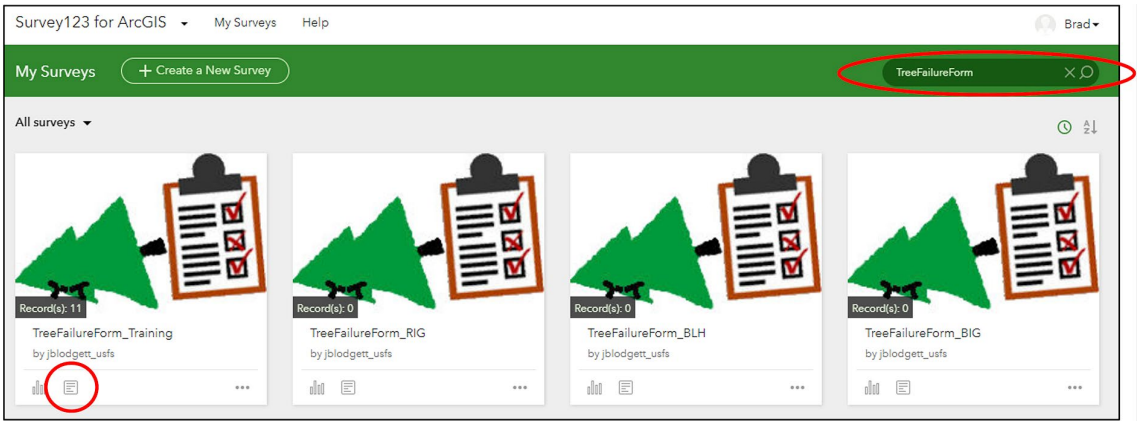

Figure 11. Type "*TreeFailureForm_****" in the search box to navigate to the appropriate form. Click the data icon (little gray box with horizontal lines below *TreeFailureForm_****) to view and download data.

Survey123 will download all surveys in the database unless otherwise specified. To reduce the number of surveys downloaded, or focus on your survey only, select just the dates of the surveys you would like to download by clicking on the calendar icon to the left of the date and then choosing a specific date or date range (**Figure 12**).

Select the output format you want by selecting the Export drop down and selecting "CSV" (CSV, shapefile, file geodatabase, etc.; **Figure 12**).

Output will be downloaded to a designated location: *e.g.*, C:\Users\username\Downloads\S123_***_CSV\HT_EvaluationForm_***_0.csv (**Figure 13**). Double click on the file to open in *Excel*. Alternatively, open *Excel*, select "file" then "open," navigate to the folder where the file is stored. Edit as necessary making sure to remove any duplicate surveys.

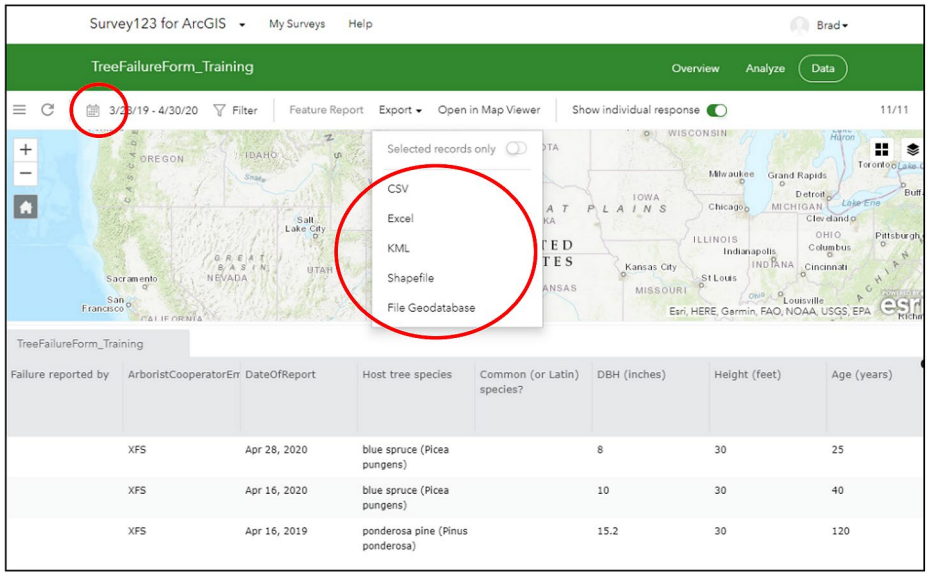

Figure 12. Under the data tab you can select the dates of the survey and the output format. Data will be downloaded to your “download” folder.

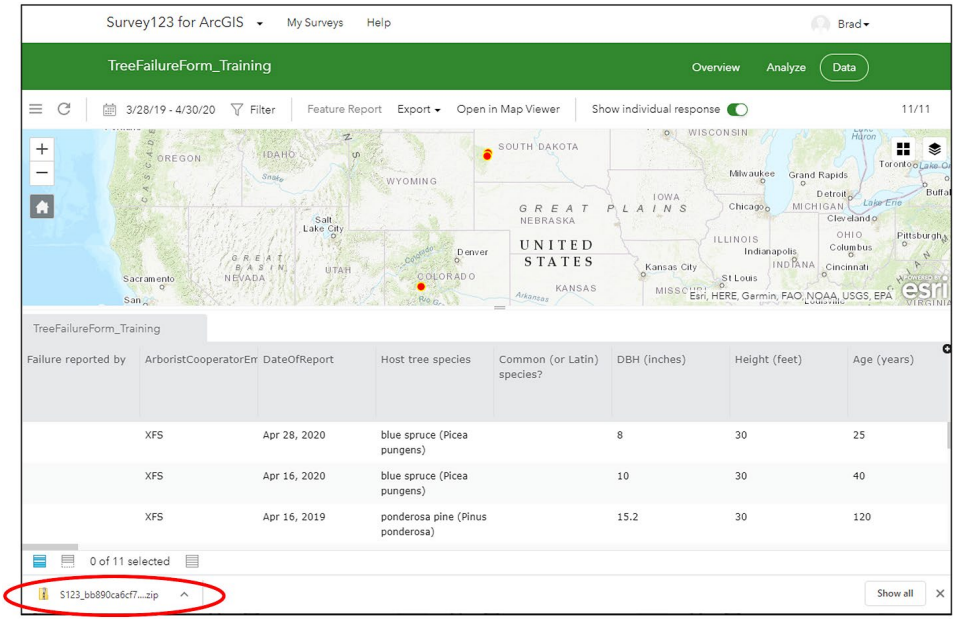

Figure 13. The file is stored with a cryptic filename. You can open the file after downloading (or “show in the folder”) and then copy-and-paste the file to a more appropriate location.

Report Templates

A single-tree report can be generated using ArcGIS Survey123 Report Templates. You can use these basic instructions to get started.

1) Open ArcGIS Survey123 in your web browser: https://survey123.arcgis.com/surveys

2) Log-in

3) If testing the forms, look for *TreeFailureForm_Training.* If using real survey data, look for *TreeFailureForm_****. The *** represents a three-letter abbreviation for each R2 National Forest.

4) Select "Data" icon, box with lines figure (**Figure 14**). This will open the associated map and data page.

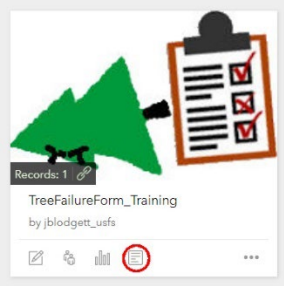

Figure 14. Select the "Data" icon.

5) Select a tree (*i.e.*, points) for a single tree report. It will make a single tree report for all trees selected if more than one tree is selected.

6) Click on "Report" (**Figure 15**) and fill in the information/select the options you want. TreeFailureForm currently has one report option, *TreeFailure_Report*, that generates a single tree report.

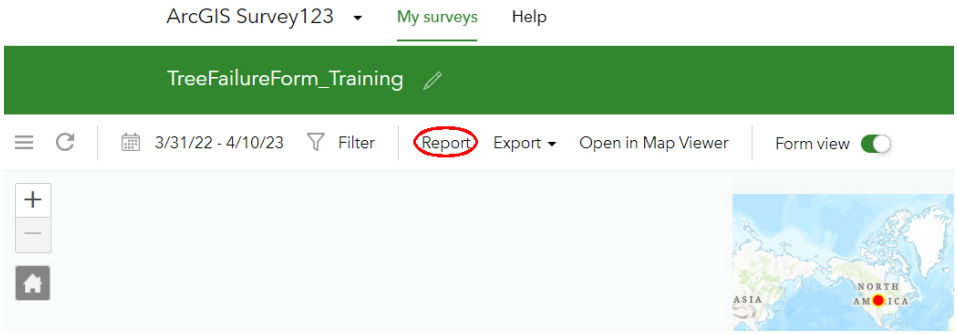

Figure 15. Select "report."

If you are using the *Training* version of the form, thus only testing reports, creating a draft version, or can use a draft version please use "Preview sample report" (**Figure 16**). Otherwise, there is a charge to the USDA-FS.

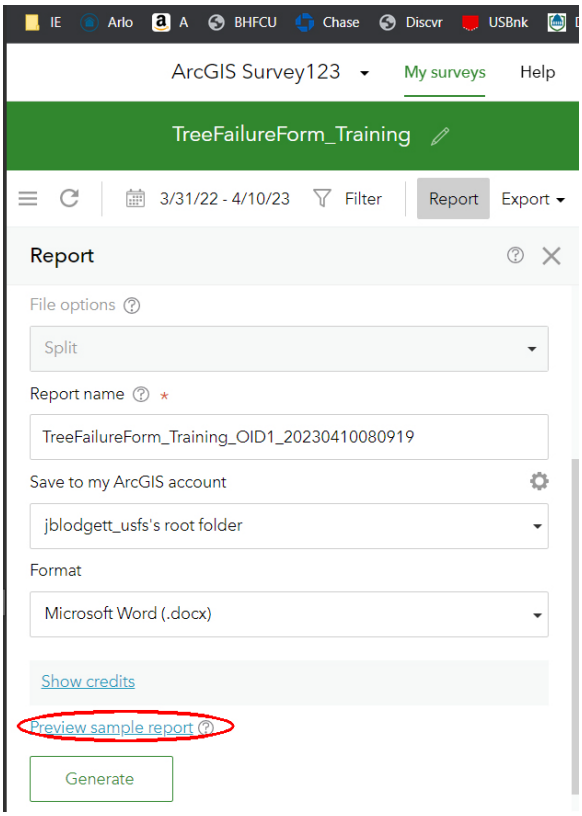

Figure 16. Please use the "Preview" option if possible.

7) Click the box: "Generate" to make a final report (there is a charge). This will allow you to download the Survey123 report in MS Word format where you can edit/format. You can also save the report in an AGOL Group folder for later downloads. These reports can be added in a Forest report, aid in tree management/removal, etc.

WHEN TO USE THE TREE FAILURE FORM

A tree failure is a structural failure or physical breakage of a tree's trunk, branch(es), or root(s). The definition does not include dead or live standing trees likely to fail, or live trees with defects that are likely to fail. Dead trees that fail should be recorded. Trees that fail during snow/ice storms, high winds, thunderstorms, etc. should be recorded. However, trees knocked over by equipment, other trees, or extreme natural catastrophes (*i.e.*, floods, tornadoes, avalanches, etc.) should not be reported. Trees intentionally removed, felled, or pushed/pulled over should not be reported even if those trees had defects. Generating reports from photographs or verbal descriptions should be avoided, since they can introduce error.

Data collection fields and terms used in this manual are in the same order as they appear on the *Tree Failure Form* (both the *e*-form and paper form). For reference, a copy of the paper report form is included at the end of this manual. Copies of the full-sized paper form and other useful information can be downloaded from Region 2's Hazard Tree Management home page: http://www.fs.usda.gov/goto/r2/fh/hazard.

The form is divided into five or six main sections of questions. Those sections include 1) General Tree Information; 2) Failure Type; 3) questions for Trunk Failure Specifics, Branch Failure Specifics, or Root Failure Specifics (only one set of questions per tree); 4) Additional Information; 5) Results of Tree Failure; and 6) Photos (if using the *e*-form).

REQUIRED DATA FIELDS AND MEASUREMENT UNITS

Four to six required data fields (marked with a red asterisk*) depending on "Failure Type" (trunk, branch, or root), must be filled in to complete a form. Required fields for all failure types include: tree species, diameter at breast height (DBH), and failure type (trunk, branch, or root). For trunk failures: tree height, height of failure above grade, and diameter at break are also required. For branch failures: diameter of the failed limb at break is also required. For root failures, the nature of the failure is required or "**Root Failure Specifics,**" along with two other variables depending on the nature of the failure.

If required fields are left blank or inappropriate information is entered on the *e*-form (*e.g.*, text for DBH), an error message will appear. This is done to assure data is entered correctly.

While only a few data fields are required, reports will have greater value if one completes as much as possible. However, it is better to enter a small amount of information versus no information.

Some data fields such as DBH and branch length require accurate measurements. All measurements should be as accurate as possible. In some cases, an experienced person can visually estimate things like tree height or height at break for branches (if they cannot be easily measured). However, the length of a fallen tree or tree parts on the ground can be easily measured with a tape measure or paced off to an acceptable accuracy.

Not all failure situations can be covered by the *Tree Failure Form*. Supplemental information can be entered in "**Additional Comments**" at the end of the report form. If a situation or feature not found in the report form is common in your area, please contact your local Forest Health Protection (FHP) office with suggested changes.

The form permits entering one tree failure at a time. There is a "**Copy**" function at the end to allow for adding additional trees with the same attributes. Be sure to make all required changes for each new entry if you use this feature.

Data must be entered in "English" (American, Imperial) units. Units are listed with the field question on the *e*-form, paper form, and in this manual.

GENERAL TREE INFORMATION

This section covers questions that apply to all failure types.

Tree Location (latitude and longitude)
Global positioning system (GPS) is used to derive locations from satellites. Use the map to automatically collect the location or to drop a pin at the tree's location. *Survey123* uses GPS to identify locations. Different maps (*e.g.*, world imagery, topography, and street maps) may be accessible to easily pinpoint the location. The map images will only display if your smart device has a data plan, the data service is on and receiving. However, GPS will work if your smart device's GPS is turned on. GPS will determine the margin of error of coordinates with a goal of five-meter accuracy. Dropping a pin will bypass the GPS but will still provide coordinates. Click the check mark on the bottom right of screen to save coordinates.

Host Tree Species*
This is a required field. Click the drop-down menu and select the tree species. Common species in your forest should be listed. Uncommon species can be added (see next, “Enter Genus and Species if Not in List”).

Enter Genus and Species if Not in List
A host tree species can be added if it is not already in the "Host tree species" list. If a genus or "Uncommon conifer/hardwood" is selected in the "Host tree species" field, a new text field will open called "Enter genus and species if not in list." Type the tree’s genus and species.

DBH (in)*
This is a required field. DBH stands for diameter at breast height, which is the diameter of a trunk measured at 4.5 feet above the ground.

Enter DBH whether this portion of the tree is still standing or is lying on the ground. For multiple stemmed trees, measure the diameter below the stem junction, if possible. If the junction is so close to the ground that it cannot be measured, each stem should be considered an individual tree. Do not enter the circumference.

Height (ft)
This is a required field only for "**Trunk failures***." Enter or estimate the total tree height prior to failure. Depending on the condition of the failure, this is measured from the root

collar to the highest twigs of the tree. The root collar is the area around the base of the tree where the trunk and root system merge; also called the root crown. In the case of a trunk failure, add the stump height to the length of the portion of the tree separated from the stump. This can be determined with a tape measure or paced off if the tree is lying on the ground. If the tree is still standing, as in the case of a branch failure, the total tree height can be visually estimated or measured. For wind-thrown trees, do not include the depth of the roots below the original soil line. Use whole numbers to the nearest foot.

Age (years)
Age can be determined by coring the tree and visually counting annual rings.

Setting
Provide information on the setting that the failed tree was in. For example, a tree may be in a national forest, but still be near a power line or in a campground. Select only one category that best represents the area's use or factor most related to the failure. Categories are:

- **Campground** - Partially or fully developed forest area intended for overnight stays, including parking areas.
- **Picnic area** - Partially or fully developed forest area intended for day-use such as picnic sites, including parking areas.
- **Trailhead** - An area with access to a hiking, biking, horseback riding, or off-road vehicle trail that allows vehicle parking.
- **Boat launches** - Area for water access that usually allows vehicle parking.
- **Interpretive areas** - Area that provides forest information (interpretive sites) not already included above. These may or may not include visitor centers and parking areas in those settings.
- **Ski areas** - Areas for downhill skiing that may or may not have other uses.
- **Roadside (rural)** - Used for forest roads not included in the other settings.
- **Utility right-of-way** - Sites within a maintained utility right-of-way, especially electrical power line right-of-ways. Other right-of-ways include gas pipelines, water flumes, irrigation ditches, and sewer pipelines.
- **Other forest site** - For sites not included above such as wildlife or other viewing areas, administrative sites, or other developed or partially developed forest sites. If using this "**Setting**" add text to describe in "**Site name**."

Site Name
This is used for a specific site name such as a campground or picnic area name. Trailheads, boat launches, ski areas, and other sites may also have specific names.

Campground Unit # or Site #
For campgrounds and picnic areas only. Enter unit or site number if designated.

Automatic Data
Some general tree location data fields are auto-generated such as: Ownership = Federal; Agency = NFS (National Forest System, USDA- Forest Service); Forest Service Region = Region 2.

FAILURE TYPE*

This is a required field. This section addresses only one question: What part of the tree failed? Categorize the failure as a trunk, branch, or root failure. Select the one that best describes the failure. Upon making a selection, questions specific to that failure type will appear on the *e*-form. For the paper form, choose only one column under "**Failure Type**."

Trunk Failure

The trunk is the main woody part of the tree connecting roots and branches. A trunk failure is the breakage of the central leader(s) above the roots, also called stem failure. Trunk failure occurs on the above ground portion of the main stem. It includes breakage of the trunk above the root collar, even if the root collar and lower trunk are below grade. Include trunk failures due to constriction by girdling roots if there is no other root involvement. Girdling roots are roots that grow around the trunk in a circular manner, constricting the trunk or other roots growth.

If the tree has two or more codominant stems, breakage in any one of the stems would be considered a trunk failure. A failure that encompasses both roots and trunk should be classified as a root failure rather than a trunk failure. In trees with a strong central leader, the trunk may fail at any point from the base to the top. In trees lacking a strong central leader, the trunk will transition to a series of scaffold branches.

Branch Failure

A branch is a secondary division of a tree's trunk or a stem arising from the central leader. Any significant aboveground failure other than failure in the main stem would be a branch failure.

Root Failure

Roots are the underground portion of the tree, including woody and non-woody tissues. Root failures are failures at or below the soil line. This includes breakage of one or more buttress roots or uplifting of the full root plate. Buttress roots are large woody roots that arise at the base of the trunk and support the transition from vertical to horizontal orientation; also called structural roots. A root plate is the area around the trunk of a tree where there is a high concentration of primary roots and other lateral/support roots. It can include failure of the roots, even if they are above grade, as well as failures that involve both roots and a portion of the lower trunk. Root failure encompasses broken roots, cut roots, and the root plate lifting out of the ground (windthrow). Failures due to constriction of the stem by girdling roots are considered trunk failures if there is no other root involvement.

TRUNK FAILURE SPECIFICS

If "**Trunk Failure**" is selected, you must provide the next two data fields.

Height of Failure Above Grade (ft)*

This is a required field if "**Trunk Failure**" is selected. Enter the height above the ground in feet at which the trunk failure occurred. Enter 0 if the trunk failure is at ground level. For breaks that are at an angle, use the midpoint between top and bottom of the break.

Diameter at Break, Measure Inside Bark (in)*

This is a required field if "**Trunk Failure**" is selected. Enter the diameter of the trunk in inches at the point where the failure occurred. If the failure is an angled break, use a measurement at the midpoint of the break. This is measured “inside the bark”. Either subtract bark thickness from the measurement of trunk diameter (diameter over-bark minus two times the average bark thickness) or measure the trunk inside the bark.

Defects Associated with Trunk Failure

This section covers common defects that are associated with trunk failures. You may select as many defects as required if the defect contributed to or was associated with the failure. Do not select a defect merely because it is present on the tree.

- **None** - No associated defects were apparent on the outside or inside of the trunk.
- **Unknown** - You were not able to examine the trunk completely and therefore were not able to determine whether any defects were present; or a defect was present, but it could not be identified. This category is not the same as "**None**."
- **Failed portion dead** - The trunk was dead prior to failure, as indicated by wood discoloration, wood moisture content, fungal growth, lack of foliage (in conifers or hardwoods in the summer), dead buds, lack of bark, or other features.
- **Decay** - Wood is degraded by a decay organism. Decay is characterized by the absence of xylem or by structurally weak xylem. Decay is the process of degradation of structural woody tissues by fungi through decomposition of cellulose, hemicelluloses, and lignin. Decay may have affected the sapwood, heartwood, or both. Sapwood is the outer and youngest layer of secondary xylem in a trunk or stem that functions in conduction and storage of water, mineral elements, and carbohydrates. Heartwood is the wood toward the center of a stem or root that has become physiologically inactive. Heartwood is often darker than sapwood and often more resistant to decay. It no longer functions for the transport of water and nutrients but may be a site for storage. Decay types include brown rot, white rot, canker-rot, and others. Discolored or dry, but structurally strong wood is not considered decay. The presence of decay can be verified in the field by pressing or picking on the suspect wood with a knife, finger, or pen. If "**Decay**" is selected, more questions will appear later in the *e*-form.

- **Canker** - A canker is a disease of the bark, cambium, or sapwood caused by fungal or bacterial organisms. Perennial cankers may have a target or concentric ring pattern. Other cankers may be diffuse, growing throughout the bark and into the trunk. Cankers may or may not have exposed xylem. Resin flow, or bleeding, may indicate the presence of a canker. Fruiting structures may be very small or large, and growing on the bark. Mistletoe and rust diseases also cause swellings that can become cankers. Mistletoe is a parasitic higher plant that has leafy and dwarf forms. Stem galls are included in "**Canker**" for the purpose of the *Tree Failure Form*. Galls in stems, branches, and roots are an abnormal localized growth, generally seen as a large knob of undifferentiated woody tissue. To qualify as a defect associated with failure, the canker must be associated with the failure and not simply present on the stem. If you select this item, and if you know the causal agent, enter later in this form. If "**Canker**" is selected, more questions will appear later in the *e*-form.
- **Codominant/Multiple stems** - Some trees contain trunks of similar size and/or relative importance arising from the base or the lower trunk, known as forks, multiple trunks, or codominant stems. To qualify, the trunks must have split at this point or be associated with the failure in other ways and not simply present in the tree.
    - **Included bark** - Bark embedded between codominant/multiple stems prevents the formation of the branch bark ridge; also called embedded bark. If "**Codominant/Multiple stems**" is selected, check for included bark. This condition can be observed if the failure occurred at a branch or stem junction. In this case, the interior of the junction can be seen.
- **Corrected lean** - A gradual bend in a tree trunk recognized by off-vertical growth in the lower stem and more vertical growth of the upper stem. This can include most trees with sweep. Sweep is a gradual bend in the trunk resulting in a change in trunk angle due to the tree trying to reach sunlight or as a result of wind. This type of lean can be recognized in a tree with a leaning lower stem and a more vertically growing top.
- **Uncorrected lean** - A trunk leaning at approximately the same angle from top to bottom or moving off vertical at a constant angle from top to bottom. This may also be called a straight lean or unnatural lean. A bow is an uncorrected lean in which the top of the tree has either a downward bend or curve at a greater angle than the lower portion of the trunk forming a constant angle throughout the tree. The lower portion of the stem often grows more vertically than the upper portion, or there may be a curve from the top to the bottom. Heavy snow loads or strong winds often can cause bows. A crook is an abrupt or broad bend in the trunk or branch. Crooks may result from loss of a codominant stem, death of a previous top, or other factor.
- **Cracks in wood** - These may be **Horizontal** or **Vertical**. A crack is the failure of wood fibers or xylem. It may be possible to differentiate between cracking that occurs at the time of failure and cracking that existed before the failure by looking for

weathering of the wood or callus growth at the crack. Select this item only if the crack was present prior to the failure.

- **Lightning injury** - Lightning strikes often leave a vertical, sometimes spiraling, line of missing bark and a valley in the sapwood midway between the bark edges. Lightning injury may also be seen as areas of missing patches of bark and wood, vertical lines with exposed wood, shattered stems, or bark totally removed from the xylem. If lightning injury predisposed the wood to decay, select this item as well as "**Decay**."
- **Animal injury** - Animals can create many types of damage to trees. The presence of tooth or claw marks in the sapwood or bark may indicate activity of porcupines, squirrels, bear, deer, beaver, voles, etc. If the animal injury was the most likely entry for decay fungus, select this item as well as "**Decay**."
- **Fire injury** - Damage caused by fire is commonly seen as blackening and charring of bark or xylem usually within several yards of the ground. In forests, many trees in an area can have fire-caused injuries.
- **Insect injury** - The primary injuries of concern are wood borers, carpenter ants, and other wood feeders. Bark beetles, shot hole borers, sucking insects (*e.g.*, aphids, scales, adelgids), and many other insects do not significantly weaken wood structure and should not be included, even if they were the primary cause of tree mortality. If the tree is dead, "**Failed portion dead**" should be selected.
- **Mechanical injury** - A human-caused injury that significantly weakened the tree as determined by the proximity of the injury to the failure point. Examples include injury from vehicles, mowers, and vandalism (hatchets, axes, saws, etc.). A nearby tree or severed branch can also cause mechanical injury by falling into the tree. Injury caused by animals should be noted as "**Animal injury**."
- **Girdling wire, etc.** - A tight wrapping caused significant mechanical constriction in trunk growth. Roots, chains, straps, wires, ropes, or other hardware can cause girdling. This does not include bark or sapwood removal by people or animals; this type of girdling should be classified as "**Mechanical injury**" if caused by humans or "**Animal injury**" if caused by animals.

Location of Decay

This section covers damage from decay fungi if present and involved in the failure. If fungi were not present or not involved in the failure, skip this section. You may check both "**Heartwood**" and "**Sapwood**" if present and associated with the failure.

- **Heartwood** - Heart rot is decay located in the inner xylem or heartwood of a trunk or branch. If the decay is a heart rot, the deteriorated wood will be mainly in the interior. Cavities may be present and are usually surrounded by non-decayed wood. If the tree has canker-rot, or the combination of heart rot and a sapwood rot, select both.
  - **Average sound wood thickness (in)** - Sound wood is wood that has not been degraded by decay organisms. With heart rots, there is usually sound wood

surrounding the decay. The sound shell contains sapwood and may also contain non-decayed heartwood. Do not include partially decayed wood in sound wood thickness. Measure the thickness of the wood outside the decay in at least three places around the circumference of the trunk. Do not include the thickness of the bark in these measurements. Take measurements at the midpoint of the failure if the failure is not horizontal. The average sound wood thickness equals the sum of the individual thickness measurements divided by the number of measurements.

- **Opening (cavity) at failure** - Heart rots often have an opening to the outside known as a cavity opening or simply a cavity. A cavity is an open wound with decay and/or a hollow. If the line of failure included the cavity opening, select "**Yes**" and determine the opening's percentage of the trunk's circumference. Occasionally there is a layer of dry wood with decay behind the opening with no bark above. This is included in the cavity opening. The percentage of cavity opening equals the width of the cavity at the point of failure divided by the circumference of the trunk at cavity height, with the result multiplied by 100. In some cases, it may be necessary to visually estimate the percentage of cavity opening rather than measuring. Enter a whole percentage (*e.g.*, 15%), not the decimal equivalent (*e.g.*, 0.15). If the cavity had no opening to the outside or if the opening was not involved in the failure, enter "**No**" and do not record a percentage.

- **Sapwood** - Sapwood-rot is decay located in the outer xylem or sapwood of a trunk or branch. If the decay is a sapwood-rot or sapwood-decay, deteriorated wood will be mostly around the trunk's exterior, and may include the bark. With this type of decay, the wood toward the center of the tree (heartwood) may not be decayed. If the tree had canker-rot or the combination of heart rot and sapwood rot, select both.
  - **Average depth of sapwood rot (in)** - Enter the average thickness of decayed sapwood at the point of failure. Make at least three measurements or visual estimates of sapwood decay thickness around the circumference of the trunk. The measurement should not include bark thickness. The average sapwood rot thickness equals the sum of the individual thickness measurements divided by the number of measurements.
  - **Circumference rotted (%)** - If sapwood rot is present, give the percentage of the circumference decayed. If decay entirely circles the trunk at the plane of failure, enter 100 percent. If the decay encompasses less than 100 percent of the circumference, determine the percentage of the circumference that is rotted. The percentage of circumference rotted equals the circumference of the decay divided by the circumference of the trunk at the same height, with the result multiplied by 100. Enter whole numbers (*e.g.*, 15%), not the decimal equivalent (*e.g.*, 0.15).

Type of Decay

Wood decay is categorized by the components of the xylem that are digested by the decay fungus and the resulting appearance. In brown rot, only the polysaccharides (cellulose and hemicelluloses) are substantially degraded. In white rot, all wood components, including polysaccharides and lignin, are degraded.

Decay produced by brown rots often has a brown color and little fibrous texture. Brown-rotted wood shrinks and breaks readily across the grain, so it is often called cubical brown rot. Decay produced by white rots tends to have a whitish color and a fibrous texture. Canker-rots are caused by a fungal disease that involves both cankering and wood decay.

- If the type of decay is not known, select "**Unknown**," or select "**Brown rot**, "**Canker-rot**," or "**White rot**." More than one selection can be made, but only select two items if one is canker-rot. Otherwise, select the one most associated with the failure.
- **Conks/mushrooms/other signs** - Conks, etc. are the woody, leathery, or fleshy spore-producing body of wood decay fungi, generally forming on the external surface of trunks and/or branches. These structures must be caused by wood decay fungi associated with the failure. They include mushrooms, conks, mycelial fans, rhizomorphs, bracket fungi (bracts), and other decay fungal structures. Select from the drop-down menu whether or not fungal structures or other signs of a fungus were visible prior to the failure by selecting "**none**," "**unknown**," or select a name listed if structures were visible and if positive diagnosis of the fungus can be made. Select "**other**" to enter a name not listed.
- **Distance from conk to failure (ft)** - If fungal structures are visible on the trunk or root collar, determine the closest distance between the fungal structure and the failure point. Enter 0 if structures are at the failure point.

Type of Canker

If "**Canker**" is selected in "**Defects associated with failure**" these additional questions appear in the *e*-form. To qualify as a defect associated with failure, the canker must be associated with the failure and not simply present on the stem.

- **Canker species** - If a positive diagnosis of the canker pathogen can be made, select the **name** from the drop-down menu. Select "**unknown**" if you do not know the name. Select "**other**" to enter a name not listed.
- **Percentage of trunk circumference (%)** - If a canker is present, determine the percentage of the trunk's circumference affected by the canker. The percentage of circumference affected equals the circumference of the canker divided by the circumference of the trunk at the same height, with the result multiplied by 100. Enter whole numbers (*e.g.*, 15%), not the decimal equivalent (*e.g.*, 0.15).

BRANCH FAILURE SPECIFICS

A branch failure is the breakage of a lateral or scaffold limb, either at or away from the attachment to the trunk. Branch failures occur in an aboveground portion of the tree that is not the trunk or main stem. If "**Branch Failure**" is selected, you must provide the next data field.

Diameter at Break Measured Inside Bark (in)*
This is a required field when "**Branch Failure**" is selected. Measure the branch diameter at or close to the break in an area representative of the branch diameter at the break. If the break is angled, measure the diameter near the center of the break. If measuring with a diameter tape, subtract two times the bark thickness to obtain the diameter of only the branch.

Total Length of Failed Branch (ft)
Measure the entire length of the failed branch from its point of attachment to the small twigs at the tips of the branch. A branch attachment is the structural union of a lateral limb to the trunk or another branch. If the failure occurred at a point other than the junction, add the length of the failed portion (the part on the ground) to the length of the stub on the tree. The stub is the portion of a branch attached to a tree after a branch break. Use whole numbers (*e.g.*, 9) rather than decimals (*e.g.*, 8.75), or fractions (*e.g.*, 8¾).

Branch Break at Attachment
Indicate whether the break occurred at the point where the branch was attached to the tree.

- "**Yes**" - The failure occurred at the point of attachment. No length measurement is required even if there are splinters sticking out of the break.
- "**No**" - The failure did not occur at the point of attachment.
  - **Distance from attachment to break (ft)** - Enter how far the break was from the attachment or the length of the stub remaining on the tree. Use whole numbers.

Defects Associated with Branch Failure
Please see "**Defects associated with failure**" in "**Trunk failure specifics**" in this guide. Substitute the word branch for trunk in the text as needed. The only major differences are: "**Corrected lean**" and "**Uncorrected lean**" are not in defects associated with branch failure.

Location of Branch Decay
Please see "**Location of Decay**" in "**Trunk Failure Specifics**" in this guide. Substitute the word branch for trunk in the text as needed.

Type of Branch Decay
Please see "**Type of Decay**" in "**Trunk failure specifics**" in this guide. Substitute the word branch for trunk in the text as needed. Although some decay species are more common in branches or trunks, most can occur in both. Therefore the "**Conks/mushrooms/other signs**" species list is the same.

Type of Branch Cankers
Please see "**Type of Cankers**" in "**Trunk failure specifics**" in this guide. Substitute the word branch for trunk in the text as needed. Although some canker species are more common in branches or trunks, most can occur in both. Therefore the "**Canker species**" list is the same.

ROOT FAILURE SPECIFICS

This category describes failures that occur at or below the soil line. It includes failures of the roots (even if they are above grade), and failures involving both the roots and a portion of the lower trunk. Root failures may be caused by broken roots, cut roots, and the root plate or ball being lifted out of the ground (windthrow or soil failure). Trunk failures due to constriction by girdling roots are considered trunk failures if the failure occurs above grade and other root failures were not involved.

If "**Root Failure**" is selected in the report form, you must provide the required data fields based on category of the root failure selected. The four "**Root Failure Specifics**" categories are (one selection is required*): "**Roots Broken and/or Decayed**," "**Roots cut/severed**," "**Root plate lifted out of ground**," or "**Roots restricted**." Choose the one that best describes the failure.

The last two failure types are similar. Both describe a type of failure in which large-diameter roots did not break and were not cut. The difference between them is for "**Root plate lifted out of ground**," there are no physical structures in the vicinity that limited root growth and were associated with the failure (common in forests). In the other category, "**Roots restricted**," a structure or other feature restricted the growth of the tree's root system that led to the failure.

Roots Broken and/or Decayed

This type of failure involves large roots (typically 2 inches or greater in diameter on larger trees) fairly close to the trunk. This category includes broken sound and/or decayed roots.

- **Diameter of largest broken root (in)*** - This is a required field if "**Roots Broken and/or Decayed**" is selected. Measure the diameter of the largest root that can be seen at the failure point. If this is an angled failure, measure the diameter at the midpoint of the break. Since root bark tends to be thin, include bark thickness in this diameter. For roots that are oval in cross-section, use the average of the large and small diameters.
- **Distance from the break to the trunk (ft)*** - This is a required field if "**Roots Broken and/or Decayed**" is selected. Determine the average distance from the break, or midpoint of an angled break, to the face of the trunk. When multiple roots are broken, use the average radial distance from the face of the trunk.
- **Condition of broken roots** - Determine whether the roots were dead or alive at the time of failure and whether decay is present and was a factor in the failure. The presence of decay can be verified in the field by pressing or picking on the suspect wood with a knife, finger, or pen. Choose one of five categories:
  - **Dead, no decay** - Most of the failed roots were dead at the time of the failure and decay was not present.
  - **Dead, decay** - Most of the failed roots were dead at the time of the failure and decay was present.
  - **Live, no decay** - Most of the roots that failed were healthy, as determined by whitish sapwood and/or live cambium, and decay was not a factor at the point of failure.
  - **Live, decay** - Most of the roots that failed were healthy, as determined by whitish sapwood and/or live cambium, but decay was present and was a factor in the tree's failure.

- **Unknown** - The root system was not visible for inspection or it could not be determined whether the roots were living, dead, or decayed at the time of failure.

Roots Cut/Severed (no decay or break)
In forest settings, root severance is most common along graded roads and can be identified by inspecting root ends for cuts. Straight cuts typically indicate root severance by a trenching machine, root cutter, or saw. Torn or shattered ends often indicate tearing by a backhoe, bulldozer, etc. Decay is often present in severed roots. However, if the severance was the most important factor in the failure, select this category over "**Roots Broken and/or Decayed**."

- **Diameter of largest cut root at cut (in)*** - Measure the diameter of the largest root that can be seen at the point of failure. If this is an angled failure, measure the diameter at the midpoint of the break. Since root bark tends to be thin, include bark thickness in this diameter. For roots that are oval in cross-section, use the average of the large and small diameters.
- **Distance from trunk to cut (ft)*** - Measure the average distance from the cut, or midpoint of an angled severance break, to the face of the trunk. When multiple roots are affected, use the average radial distance from the face of the trunk.
- **Percent of roots cut (%)** - Measure or estimate the percentage of roots affected. It may help to divide the area around the tree into quadrants.

Root Plate Lifted Out of Ground
This is one of two categories used for windthrow or soil failure (the other category is "**Roots Restricted Due to**"). In this category, smaller size roots are broken at a distance from the trunk, and the roots were not restricted in growth due to an impenetrable barrier. Soil is often attached to the root plate.

- **Root plate radius (ft)*** - Measure the average root plate radius from the face of the trunk to the edge of the root plate.
- **Root plate depth (in)* -** Measure or estimate the average depth halfway from the trunk center to the outer edge of the root plate.

Roots Restricted Due to
Like the previous category "**Root Plate Lifted Out of Ground**," this is a type of failure in which large-diameter roots did not break and were not cut. The difference between them is there was a physical structure or feature that restricted root growth that was associated with the failure. This physical structure or feature restricted the space available to the tree's roots.

- Select the restricting feature(s) involved*
  - **Natural features** - Examples include rocks, streams, high water table, valleys, cliffs, soil density or texture changes, hard pans, or another naturally occurring feature that restricted root growth and led to tree failure.
  - **Other** - Other features that restrict root growth include man-made barriers associated with buildings, walls, or other structures; open trenches that did not sever roots; or another feature not listed above. If "**Other**," add a description in "**Why did this failure occur?**" later in the form.
- **Distance from trunk to restriction (ft)*** - If root restriction caused the failure, measured the distance from the trunk face to the closest portion of the restriction.

- **Percentage of root zone restricted (%)** - Estimate the percentage of root zone taken up by the feature(s) involved.
- **Root collar girdled** - If growth was restricted in the root collar area, select "**Yes**"; if not, select "**No**." A girdling root, wire, landscape fabric, or other factor can cause a restriction.
    - If "**Yes**," enter the **Percentage circumference girdled**. Calculate this by dividing the length of the restriction by the root collar circumference at the plane of the girdling and multiply by 100.

Type of Decay
Only use this section if decay fungi are present and decay was involved in the failure. This will only be an option in the *e*-form, if both "**Roots Broken and/or Decayed**" is selected and "**Dead, decay**" or "**Live, decay**" are selected.

- **Percentage of roots decayed (%)** - If decay is present on the buttress or structural roots of the failed tree, report the percentage of roots decayed. This can be calculated by dividing the number of buttress roots with significant decay by the total number of buttress roots and multiplying by 100. If it is not possible to determine the number of roots, use a percentage of the circumference of the butt or lower portion of the trunk that has decayed roots.
- **Conks/mushrooms/other signs** - Indicate whether fungal fruiting structures or other signs of the causal fungus were present. Signs include mushrooms, conks, mycelial fans, rhizomorphs, and other structures. Select from the drop-down menu whether or not fungal structures or other signs of a causal fungus were visible prior to the failure by selecting "**none**," "**unknown**," or select a name listed if structures were visible and if positive diagnosis of the causal fungus can be made. Select "**other**" to enter a name not listed.
- **Average sound wood thickness (in)** - Sound wood is wood that has not been degraded by decay organisms. Do not include partially decayed wood in sound wood thickness. Measure the thickness of the wood outside the decay in at least three places around the circumference of the root. Take measurements at the midpoint of the failure if the failure is not horizontal. The average sound wood thickness equals the sum of the individual thickness measurements divided by the number of measurements made.
- **Rot type** - Wood decay is categorized by the components of the xylem that are digested by the decay fungus and the resulting appearance. In brown rot, only the polysaccharides (cellulose and hemicelluloses) are substantially degraded. Decay produced by brown rots often has a brown color and little fibrous texture. Brown-rotted wood shrinks and breaks readily across the grain; it is often called cubical-brown rot. In white rot, all wood components including polysaccharides and lignin are degraded. Decay produced by white rots tends to have a whitish coloration and residual fibrous texture. If the type of decay is not known select "**Unknown**." Otherwise select "**brown rot**" or "**white rot**."

Site/Soil Conditions
Enter the following soil information regardless of the type of root failure involved.

- **Soil composition** - The predominant soil texture component of the soil at the failure site. Select the one that describes the soil composition. If this is not known, select "**Unknown**."
- **Soil moisture at the time of failure** - Estimate the relative water content of the soil at the time the failure occurred and select the one that best describes the condition.
  - **Unknown** - If water content was not known.
  - **Dry** - Soil indicates there was no rain prior to failure.
  - **Flooded** - Soil indicates the area around the tree had been covered with standing or moving water at the time of failure, and the soil was saturated.
  - **Moist** - Soil indicates there had been rain recently but the soil was neither dry nor saturated.
  - **Saturated** - Soil indicates that there was a significant amount of rain prior to the failure or freestanding water was present on top of the soil. If the root-plate hole has water, it typically indicates a saturated condition.
- **Restricted rooting depth due to** - Select items in this section if the soil beneath the tree was impenetrable to root growth. You may check as many of these as needed, as long as they were associated with the failure. This includes soil directly beneath the tree to a depth of approximately 3 feet. If the restriction was at a greater depth, select these items only if it is obvious that a root restriction existed. The presence of these factors at a greater depth without evidence of root restriction does not warrant their inclusion. Root depth restricting factors include:
  - **None** - If no root restriction exists.
  - **Compacted** - Compacted subsoil conditions exist when the subsoil has been mechanically pressed down during construction or other human activities. Compaction may also occur naturally when soils with high clay content are present without good soil structure. If only the surface soil is compacted, note this in "**Other site conditions**" (below) rather than here.
  - **High water table** - Like poor drainage, this condition exists regardless of rainfall or soil texture. High water tables are often found near bodies of water such as streams or lakes.
  - **Other** - Conditions that affect downward root growth not listed. A description of these conditions should be given in the "**Additional Comments**."
  - **Poor drainage** - This is usually seen as a saturated layer of soil with the smell of anaerobic decomposition and a gray color. Mottled (light and dark) soil is often seen immediately above the saturated layer. Poor drainage conditions usually exist due to high clay content that prevents drainage.
  - **Shallow or layered soil** - This restriction may be due to impenetrable rock, rock ledge, or incompatible soil texture layers that restrict downward root growth.
  - **Unknown** - If not known. This category is not the same as "**None**."
- **Other site conditions** - This section includes other conditions that influenced the tree failure. You may check as many of these as needed, if they were associated with the failure.
  - **None** - If no other root related problems exist.
  - **Compaction** - Surface soil can be compacted by construction and other human or animal activities. This category is for surface soil compaction rather than the subsoil compaction in the previous section. Compaction must be high enough to have restricted root development.

- **Fill soil against trunk** - Select this item when buttress roots are not visible; this can be selected in conjunction with grade change or other factors.
- **Grade change** - This is when a layer of soil is added (fill) or removed (cut) from around a tree within the tree's dripline. Grade change is usually associated with construction around a tree but may be caused by landslides or other natural actions. Do not include cuts or fills of less than 2 inches.
- **Soil eroded from around roots** - Soil has been washed out or otherwise removed from around the buttress roots. This is often seen along streams, shorelines, places where water flows across the soil surface, or in association with some digging animals.
    - **Depth of excess soil (in)** - Use to indicate the change in soil depth.

Defects Associated with Root Failure

This section contains common defects associated with root or soil-related failures. You may check as many of these as needed, as long as they were associated with the failure.

- **None** - No defects were apparent on the outside or inside of the buttress roots.
- **Unknown** - You were not able to examine the roots completely and therefore were not able to say whether defects were present; or a defect was present, but it could not be identified. This category is not the same as "**None**."
- **Fire scar/injury** - Damage caused by fire was visible on the buttress roots of the tree. Fire injury is commonly seen as blackening and charring of the bark or xylem usually within several yards of the ground. Trees where forest fires or prescribed burns were severe will have symptoms at higher levels in the trees. In forests, many trees in the area usually have the same symptoms.
- **Basal wound** - This is mechanical damage to the buttress or first-order lateral roots. Basal damage may be caused by equipment, lightning, insects, or disease. If fire or animals caused the damage, note this under the specific categories (**Fire scar/injury** or **Animal injury**). If a lawn mower or other lawn maintenance related device caused the damage, but not on the basal portion of the trunk, select "**Surface root**."
- **Corrected lean** - A sweep is a gradual bend that may result from a change in trunk angle to reach sunlight or as a result of wind. This type of lean can be identified in a tree with a leaning lower stem and a more vertically growing top. This type of lean is also referred to as a natural lean.
- **Uncorrected lean** - A trunk that is leaning at approximately the same angle from top to bottom. It is also known as a straight lean or unnatural lean.
- **Animal injury** - Animals can create many types of mechanical damage to trees. Animal injury can usually be confirmed by the presence of tooth or claw marks in the sapwood or bark. Animals that commonly cause injury to trees include porcupines, squirrels, bears, elk, deer, beavers, and voles.
- **Cracks in trunk prior to failure** - A crack is a vertical or horizontal split in the lower stem and buttress roots involving bark, cambium, and xylem. It may be possible to differentiate between cracking that occurs at the time of failure and cracking that existed before the failure by evidence of weathering on the wood. Select this item only if the crack was present prior to the failure.
- **Surface roots** or **root collar wounded** - Mechanical wounds to the root collar area, buttress roots, or first-order lateral roots caused by lawn mowers or other devices. This category is a more specific subset of "**Basal wound**."

ADDITIONAL INFORMATION

This section contains information not previously covered and applies to all failure types.

- **Were defects associated with failure visible before failure?** - In trying to predict tree failures, it is important to know if the defect associated with the failure was externally visible to a trained observer prior to failure. Select "**Yes**" if the most important defect contributing to the failure was visible prior to the failure; if it was not visible select "**No**." Sometimes it is hard to determine whether the defect was visible; in that case, select "**Unknown**."
- **At the time of failure the tree was** - If the entire tree was dead prior to failure as indicated by the lack of foliage (in conifers or hardwoods in the summer), dead buds, lack of bark, wood moisture content, or other features select "**Dead**." Select "**Declining**" if the tree was alive but very unhealthy. A declining tree means a tree with a progressive reduction in health of organs or the entire plant, usually caused by a series of interacting factors. Declining trees are still alive in at least a portion of their trunk, root, and branch systems. Crowns exhibit dieback or thinning. Leaves may be green or chlorotic yellow and sparse and/or stunted. The crown is the portion of the tree that bears leaves and branches, from the lowest branch to the topmost leaf. For live trees, the majority of the crown should be healthy. Select "**Alive**" if the tree was alive and mostly healthy. If not known select "**Unknown**."
- **Were trees recently removed in vicinity of failed tree?** - Determine whether other trees were removed from the area adjacent to the failed tree within the previous 4 years. Tree removal may have been during forest-thinning, removals due to construction, or removal of adjacent high-risk or dead trees. Select "**Yes**," "**No**," or "**Unknown**."
- **Is there a history of prior failure at the site?** - Determine whether other trees have failed in a similar way (trunk, branch, or root) near this failure. For branch failures, have there been other branch failures on this tree? This may represent a disease center, site-related problem, lack of wind-resisting strength, or another factor. Select "**Yes**," "**No**," or "**Unknown**."
- **Month of failure and Year** - Enter if known or leave blank if you are not able to determine.
- **Aspect** - Aspect is the compass direction that a slope faces. If the tree is growing on a slope, determine the direction of the slope.
- **Slope (°)** - If the tree is on a slope, determine the amount of slope as measured in degrees.
- **Above average wind** - Select "**Yes**" if wind speed was above average when the damage occurred or "**No**" if it was not. In many cases "**Unknown**" should be selected.
- **Precipitation** - Select the type of precipitation at the time of failure or that was related to the failure. If not known select "**Unknown**." Select the one that best describes the condition.
- **Why did this failure occur?** - Describe factors that you believe caused the tree failure. This is especially important if you were not able to find a category in "**Failure type**" that accurately described the cause. Provide as much detail as needed.

RESULTS OF TREE FAILURE

This section covers the results and costs of the tree failure. Select the type(s) of damage that occurred due to the tree failure. Multiple selections can be made.

- **None** - No damage beyond the loss of the tree or branches. This can include minor landscape disturbance. If the tree needed to be removed, select "**Removal of this tree**."
- **Property damage** - Damage to personal property such as vehicles, cabin, picnic tables, pavement, or other item(s).
- **Personal injury** - A person was injured or killed due to the tree failure. Do not include injuries sustained during cleanup of the failed tree, but do include injuries indirectly caused by the failure; for example, injury resulting from a fire caused by a tree failure. Describe any personal injuries in "**Additional comments**," below.
- **Fire** - A fire started as a result of the tree failure; for example, a lightning strike to the tree or the tree contacting a power line.
- **Power outage** - The tree failure damaged a power line which caused a power outage.
- **Removal of this tree** - The only damage was that the failed tree or portion(s) of the tree were removed.
- **Loss of other trees** - The failed tree fell into an adjacent tree(s) resulting in the death, serious injury, or removal of other trees.
- **Other damage** - Damage occurred, but it does not fit another category. Describe the damage in "**Additional Comments**," below.

- **Property damage estimate ($)** - Enter an estimate in dollars to replace damaged items.
- **Cleanup costs ($)** - Dollar value to clean-up the damage including removal, hauling, and disposal costs. Hourly salary and cost of equipment should be included.
- **If personal injury describe below** - A brief description of bodily injury to a person.
- **Additional comments** - Include descriptions of target(s) that were damaged including the type/severity of the damage. This can include information that quantifies the damage(s) associated with the failure. This response may also include any other relevant information associated with the failure.

PHOTOS

Photographs can be added using the *e*-form. We encourage people to take relevant photographs that help define the failure.

- **Tree and surrounding** - A photo to depict the failure scene including the failed tree and/or other important landmarks.
- **Main failure** - A photo to help define why the tree failed. This photo should include the point of failure.
- **Other** - A secondary photo to help define the failure, such as one showing a secondary cause of the failure, resulting damage from the failure, a disease associated with the failure (decay conk or canker disease), etc.

TREE FAILURE EVALUATION FORM

USDA Forest Service **TREE FAILURE EVALUATION** Rocky Mountain Region

* = required field
☐ = can select more than one
❍ = select only one

Host tree species *_____
DBH*_____in Height_____ft Age_____years

Setting
❍ Campground ❍ Picnic area ❍ Trailhead ❍ Boat launches
❍ Interpretive areas ❍ Ski areas ❍ Road side (rural) ❍ Utility right-of-way
❍ Other forest site_____
Site name_____ Unit #_____

FAILURE TYPE* (select one)

❍ TRUNK FAILURE

Trunk Failure Specifics
Height of failure above grade*_____ft
Dia. at break (inside bark)*_____in

Defects Associated with Failure
☐ None ☐ Unknown
☐ Failed portion dead
☐ Decay ☐ Canker
☐ Codominant/Multiple stems
☐ Included Bark
☐ Corrected lean
☐ Uncorrected lean
☐ Cracks in wood - horizontal
☐ Cracks in wood - vertical
☐ Lightning Injury
☐ Animal Injury
☐ Fire Injury
☐ Insect Injury
☐ Mechanical Injury
☐ Girdling wire, etc.

Location of Decay
☐ HEARTWOOD
Avg. sound wood thickness_____in
Opening (cavity) at failure
❍ Yes,trunk circ._____% ❍ No
☐ SAPWOOD
Avg. depth of rot_____in
Circumference rotted_____%

Type of Decay
❍ Unknown ❍ Brown rot
❍ Canker rot ❍ White rot
Conks/mushrooms/other signs
None/unknown/name_____
Distance from conk to failure_____ft

Type of Canker
Canker species_____
Trunk circumference_____%

❍ BRANCH FAILURE

Branch Failure Specifics
Dia. at break (inside bark)*_____in
Total length failed branch_____ft
Break at attachment ❍ Yes ❍ No
If No, distance from the attachment to break_____ft

Defects Associated with Failure
☐ None ☐ Unknown
☐ Failed portion dead
☐ Decay ☐ Canker
☐ Codominant/Multiple stems
☐ Included Bark
☐ Cracks in wood - horizontal
☐ Cracks in wood - vertical
☐ Lightning Injury
☐ Animal Injury
☐ Fire Injury
☐ Insect Injury
☐ Mechanical Injury
☐ Girdling wire, etc.

Location of Decay
☐ HEARTWOOD
Avg. sound wood thickness_____in
Opening (cavity) at failure
❍ Yes,branch circ._____% ❍ No
☐ SAPWOOD
Avg. depth of rot_____in
Circumference rotted_____%

Type of Decay
❍ Unknown ❍ Brown rot
❍ Canker rot ❍ White rot
Conks/mushrooms/other signs
None/unknown/name_____
Distance from conk to failure_____ft

Type of Canker
Canker species_____
Branch circumference_____%

❍ ROOT FAILURE

Root Failure Specifics*
❍ **Roots broken and/or decayed**
Dia. of largest broken root*_____in
Distance from trunk to break*_____ft
Condition of broken roots
Dead: ❍ no decay ❍ decay
Live: ❍ no decay ❍ decay
❍ Unknown
❍ **Roots cut/severed** (no decay/break)
Dia. of largest cut root at cut*____in
Distance from trunk to cut*_____ft
Roots cut_____%
❍ **Root plate lifted out of ground**
Root plate radius*_____ft
Root plate depth*_____in
❍ **Root restricted due to**
☐ Natural Feature ☐ Other*
Distance from trunk to restriction*___ft
Root zone restricted_____%
Root collar girdled ❍ Yes ❍ No
Circumference girdled_____%

Type of Decay
Roots decayed_____%
Conks/mushrooms/other signs
No/unknown/or Name_____
Avg. sound wood thickness_____in
Rot type: ❍ Unknown ❍ Brown ❍ White

Site/Soils Conditions
Soil composition ❍ Sand ❍ Silt ❍ Loam
❍ Clay ❍ Rock/gravel ❍ Unknown
Soil moisture at time failure ❍ Unknown
❍ Dry ❍ Flooded ❍ Moist ❍ Saturated
Restricted rooting depth due to
☐ None ☐ Compacted ☐ High water table
☐ Other ☐ Poor drainage ☐ Shallow soil
☐ Unknown
Other Site Conditions ☐ None
☐ Compaction ☐ Fill soil against trunk
☐ Grade change ☐ Soil eroded
Depth of excess soil_____in

Defects Associated with Failure
☐ None ☐ Unknown
☐ Fire scar/injury ☐ Basal wound
☐ Corrected lean
☐ Uncorrected lean ☐ Animal Injury
☐ Cracks in trunk prior to failure
☐ Surface roots ☐ Root collar wounded

ADDITIONAL INFORMATION

Were defects associated with failure visible before failure?
❍ Yes ❍ No ❍ Unknown

At time of failure the tree was…
❍ Dead ❍ Declining ❍ Alive ❍ Unknown

Were trees recently removed in vicinity of failed tree?
❍ Yes ❍ No ❍ Unknown

Is there a history of prior failures at site?
❍ Yes ❍ No ❍ Unknown

Month of failure_____ **Year of failure**_____

Aspect:
❍ Not applicable/Flat ❍ N ❍ NE ❍ E ❍ SE ❍ S ❍ SW ❍ W ❍ NW

Slope:
❍ No slope ❍ ≤5° ❍ 5-15° ❍ 15-30° ❍ 30-45° ❍ >45°

Above average wind ❍ Yes ❍ No ❍ Unknown

Precipitation: ❍ None ❍ Rain ❍ Snow ❍ Ice ❍ Unknown

Why did this failure occur?

_____
_____
_____

RESULT OF TREE FAILURE
☐ None (No damage other than the failure) ☐ Property damage ☐ Personal injury
☐ Fire ☐ Power outage ☐ Removal of this tree ☐ Loss of other trees ☐ Other damage
Property damage estimate $_____ Cleanup costs $_____

Additional comments (injury, target, damage, etc.)

_____
_____
_____
_____
_____
_____
_____

Your name_____**Date**_____