USDA
United States Department of Agriculture

Digital Mobile Sketch Mapping (DMSM)

Updates to Forest Health Survey with DMSM

Forest Service

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Introduction

The Digital Mobile Sketch Mapping (DMSM) project is about more than replacing the legacy Digital Aerial Sketch Mapping (DASM) hardware and software. DMSM standardizes several updates to aerial detection survey (ADS) methodology with an eye toward more effective integration with ground survey and remote sensing. This document provides guidance on the most significant updates to survey procedures implemented by, or associated with, the DMSM application. The bullets below summarize these updates. The discussion section that follows provides additional details, including the rationale for each update and, where applicable, guidance on appropriate implementation:

- **Central database.** Survey data collected with DMSM is uploaded (synched) from the tablet to a central database. Authentication to upload and download data from this secure database requires an ArcGIS On-Line (AGOL) login. Users who do not already have an AGOL login, should contact FHAAST and one will be provided. FHAAST has developed an ArcMap desktop extension to simplify post-mission editing of survey data.
- **Grid cells** as a 3rd option, along with points and polygons, for mapping damage features. Grids are available in resolutions of 240, 480, 960 or 1920-square meters (~14, 57, 228, or 911 acres).
- **5-class, Percent-of-tree-canopy-affected method for mapping damage intensity on areas.** DMSM requires a 'percent-class' call on all damage areas (cells and polygons) regardless of damage type.
- **5-class, Number of affected tree method for mapping damage intensity on points.** Points are used for mapping isolated clusters of damaged trees.
- **The DMSM database does not include separate fields for defoliation SEVERITY and PATTERN.** Instead of a separate field for within–tree severity based on the percent of foliage affected, the list of DMSM Damage Types has been expanded to differentiate 3 defoliation severity levels; < 50%, 50-75%, and > 75% average defoliation among affected trees.
- **Quick Keys:** similar to air survey "cheat sheets', Quick Key lists pre-define for a particular state, region, or survey area the DCA, Host, and Damage Type combinations that surveyors expect to map from the plane.
- **Host calls are species-specific:** Unlike prior ADS guidelines that allow forest types (e.g. Western fir-spruce type) or genera (e.g. 'Spruce'), DMSM requires species-specific host calls.
- **Host groups:** To accommodate cases where a damage causing agent affects multiple hosts and where it's not possible or practical to differentiate damage for each individual host from the air, DMSM will accommodate "host groups" made up of up to 5 tree species.
- **Damage area features may overlap.** The percent-class method allows acres of damage estimation without double counting overlapping damage areas.
- **Avoid adding secondary aerial observations for the same damage feature.** Given the inherent imprecision of aerial survey, it is sufficient to label damage features with the most prevalent damage type and/or the primary causal agent.

Discussion

Central database:

Survey data collected with DMSM is uploaded (synched) from the tablet to a web-enabled central server geo-database (i.e. a secure feature service). Authentication to upload and download data from this secure feature service requires an ArcGIS On-Line (AGOL) organizational account. Users who already have an AGOL account should email that login name to Sage Sheldon (Sage.Sheldon@usda.gov) or JD Mullen (james.mullen@usda.gov) at FHAAST to add your login to the DMSM group on AGOL. Users who do not already have an AGOL login, should contact Sage or JD and one will be provided.

FHAAST has developed an ArcMap add-in to provide simple and secure access to the central DMSM geo-database. These custom desktop tools build on standard ArcGIS functionality for check-in and check-out of database replicas. The DMSM Desktop Tools include wizards to help authenticated user's check-out and check-in features they have permissions to edit while allowing read-only display for all features of interest, regardless of edit permissions.

Grid cells:

Grid cells are an efficient way to map damage in busy outbreak conditions or diffuse damage without distinct boundaries. A surveyor's choice of grid cell resolution (240, 480, 960 or 1920 meters) provides clients and users with valuable insight on the observational scale and precision of the data.

The choice of which type of feature (points, polygons or grid cells) surveyors should use to map damage depends on their ability to identify the size, shape, and position of damage from the air and accurately render that information on a map.

1. **Points** are recommended for:
    - Small clusters of tree damage (generally areas less than 10 acres).
    - Point features are particularly useful where the extent of damage (size and shape) is less important than recording a location for a follow-up visit.
    - Nascent clusters of tree damage from sudden oak death or southern pine beetle, or damage to individual or small groups of relatively uncommon but important species such as sugar pine and Port Orford cedar are examples where points might be preferred over polygons.
2. **Polygons** are a good choice:
    - When boundaries around areas of tree damage are discrete and obvious from the air and easy to locate and orient on DMSM base data.
    - In cases where the damage boundaries (size and shape) are distinct but there is a lack of identifiable landmarks on base imagery to confidently locate position, grid cells may be a better choice as a way to communicate that positional uncertainty.

3. **Grid cells** are recommended when:
    - The extent of the damage is difficult to characterize.
    - The boundaries of observations are difficult to render and may extend beyond a reasonable sight/mapping distance (e.g. greater than 2 miles from the plane).
    - Damage is widespread, often diffuse, and difficult to render precisely on a map.
    - Examples where a grid cell approach would be particularly useful include light, scattered damage such as caused by Ips outbreaks in the Southeast, beech bark disease and emerald ash borer in the Lake States.
    - Grid cells may be less useful in complex mountainous terrain where 2-Dimensional screen renderings of grids poorly match the view from the plane.

Damage Intensity: Percent-calls for areas, Tree-counts for points:

On cells and polygons, DMSM characterizes damage intensity by the percent of live and standing dead trees within the cell or polygon that are damaged/recently dead. For small groups of damaged trees captured as point features, DMSM uses tree count classes.

Referred more simply as 'percent-class', DMSM requires a percent-of-tree-canopy-affected call on all damage areas (cells and polygons) regardless of damage type. Similarly, a tree count range of affected trees is required for all damage features represented as points.

The list of Damage Intensity classes for areas and points is shown below:

PERCENT AFFECTED*
Very Light (1-3%)
Light (4-10%)
Moderate (11-29%)
Severe (30-50%)
Very Severe (>50%)

NUMBER OF TREES**
1
2-5
6-15
16-30
31-99

*Percent Affected used for damage polygons & grid cells
** Number of Trees used for damage point features

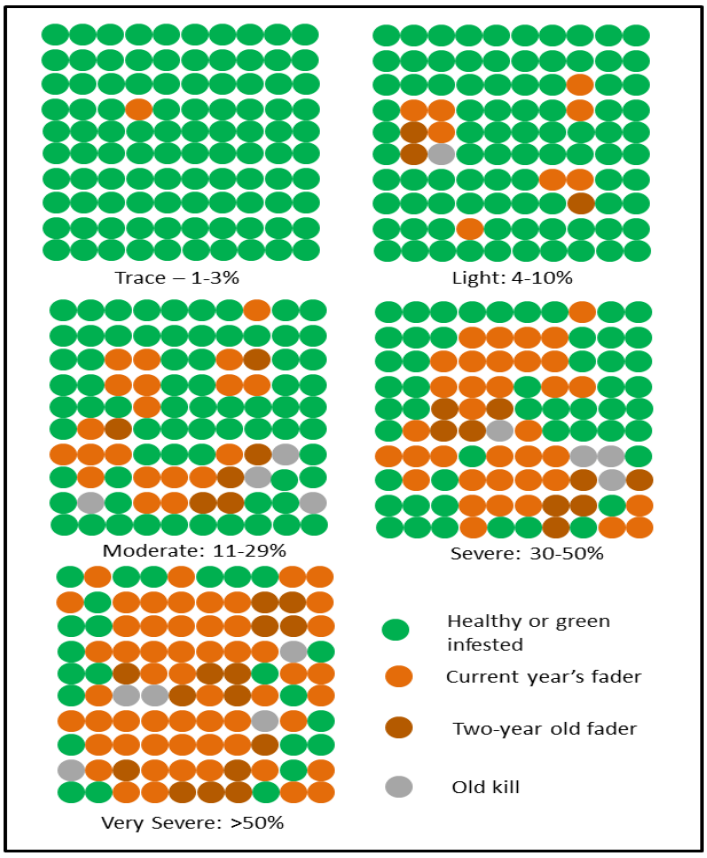
Percent classes for areas

The percent-class method equates a single large crown tree with a similar canopy area comprised of tightly spaced smaller crown trees.

This percent or ratio can be expressed as:

$$\frac{\text{Number (area of canopy) of damaged or recently dead trees within the damage area polygon or grid cell}}{\text{Number (area of canopy)of all live and standing dead trees within the damage area polygon or grid cell}}$$

Note that the treed area (the denominator in the percent of trees call) is all trees, not just hosts, nor just live trees but standing dead as well. In the graphic below, 'Old kill' and 'Two-year old fader' represent standing dead trees considered part of the treed area denominator:



Note that the treed area (the denominator in the percent of trees call) is all trees, not just hosts, nor just live trees but standing dead as well. In the graphic below, 'Old kill' and 'Two-year old fader' represent standing dead trees considered part of the treed area denominator:

Intensity : 'Very Severe > 50% of trees (canopy area)'	Intensity: 'Very Light 1 -3% of trees (canopy area)

Also note that non-treed areas (water, roads, meadows, etc.) that may cover part of the damage area polygon or grid cell do not factor into the percent-class call. It is the live and standing dead trees within the polygon or grid cell, and ***not the area of the polygon or grid cell as a whole***, that represent the denominator in this equation. As a consequence, it is not necessary to create 'donut hole' exclusions for pockets of non-treed area inside of a damage area polygon. Post-processing will use a treed / non-tree GIS layer and the percent-call to generate 'acres-of' damage summaries that factor out non-treed and undamaged-treed areas within damage polygons and grid cells.

Advantages of the percent-class method for larger areas include:

- Better correlation with satellite-based remotely sensing than TPA.
- Enables data summaries that account for the non-affected areas within damage polygons or grid cells (i.e. allows estimates for acres of damage in addition to the traditional acres with damage).
- Allows acres of damage summaries that can account for overlapping damage areas.
- For larger areas of damage, training surveyors to select from a 5-category, percent of treed area affected pick-list is more straight-forward and will produce more consistent results across surveyors and regions than a TPA-based method.
- Using percent range classes more accurately represents the precision of aerial survey than assigning specific TPA values.

Relative to a percent-call, estimating the number of affected trees for damage areas larger than 10 acres becomes progressively more difficult and inaccurate as the size of the damage area increases. However, choosing one of five tree count class for small clusters of damaged dominant or co-dominant trees is an accurate and repeatable method for characterizing damage intensity on point features.

Damage Type updates: No separate fields for SEVERITY and PATTERN:

With the notable exception of defoliation, the list of DMSM damage types remains unchanged from prior aerial survey standards. 'No damage' should only be used if a field check determines that an aerial survey feature was incorrectly mapped as damaged (see table below):

DMG_TYPE CODE	DMG_TYPE NAME
2	Mortality
3	Crown Discoloration
4	Crown Dieback
5	Topkill
6	Branch Breakage
7	Main stem Broken or Uprooted
8	Branch flagging
9	No damage
11	Mortality - Previously Undocumented
12	Defoliation < 50% of leaves defoliated
13	Defoliation 50-75% of leaves defoliated
14	Defoliation > 75% of leaves defoliated
18	Other Damage (known)
19	Unknown Damage

Defoliation:

The decision to create three defoliation damage types based on average foliage loss for affected trees was designed to streamline aerial survey by eliminating a separate click to record SEVERITY. The requirement to attribute all damage types (including defoliation) with a percent-class call made it unnecessary to have a separate PATTERN field.

The difference between the percent-call and the three defoliation damage types can be confusing. The defoliation severity modifiers are within-tree measures indicating the average foliage loss for affected trees; the percent-call is an among-tree attribution representing the proportion of defoliated trees among all standing trees in the polygon or cell. See details on using DMSM to map defoliation.

Quick Keys:

Quick Key lists define for a particular state, region, or survey area the DCA, Host, and Damage Type combinations that surveyors expect to map from the plane. The up-front effort to define Quick Keys pays dividends by streamlining data collection, supporting consistency across surveyors, and reducing attribution errors.

Aerial Survey Focus: When developing your Quick Keys and Host Groups, focus on what can be discerned from the air in terms of specific causal agent and how precisely host species can be identified. There is no practical advantage to creating Quick Keys for very specific damage agent and host combinations that can only be identified with an on-the-ground tree examination.

With the exception of changing Quick Key colors, which can be customized by the DMSM software on the tablet, Quick Keys and Host Groups must be pre-defined and loaded into the DMSM database server ahead of flying aerial survey. Contact Mark Zweifler (mark.zweifler@usda.gov) with requests to modify a Quick key list.

Quick keys, Quick key lists and Host Groups are specific to each region. In DMSM users will only see the Quick Keys and Host Groups for their specified region.

Note: Quick Key lists can be quite long (some states and regions have lists with over 100 Quick Keys) but DMSM will only display 18 Quick Keys at one time without scrolling. DMSM has tools to efficiently find and display the 18 Quick Keys most relevant to what you are currently mapping.

All Quick key lists should include a set of broadly applicable Quick Keys to cover situations where it is not possible to identify the causal agent and/or host (e.g. 'unknown defoliation on hardwoods', 'unknown mortality on conifers', etc.). These 'generic' quick keys can also be useful in cases where damage agent and type are known but an appropriate quick key was not yet defined and available in DMSM.

To summarize **Quick Keys** are a pre-set combination of:

- **Damage Type** (e.g. Mortality, Defoliation, etc.)
- **Damage Agent** (e.g. Southern Pine Beetle, Hail, Forest Tent Caterpillar, etc.)
- **Host or Host Group** (an individual tree species or set of tree species)
- A **label** that you will see on the DMSM screen - must be no more than 12 characters.
- A **color** that can help surveyors differentiate the type of quick key that they wish to select (e.g. red for mortality, shades of yellow for defoliation, etc.). These color choices can also be used in DMSM to set the font color for damage feature labels.

Species-specific host calls:

Unlike prior ADS guidelines that allow forest types (e.g. Western fir-spruce type) or genera (e.g. 'Spruce'), DMSM requires species-specific host calls.

While traditionally annual forest pest surveys are summarized by forest pest or damage type, FHP would like to move toward more reporting by tree species with greater ability to identify threats to vulnerable tree species. That goal requires species-specific host information on all damage features.

Host Groups:

To accommodate cases where a damage causing agent affects multiple hosts and where it's not possible or practical to differentiate damage for each individual host from the air, DMSM will accommodate "host groups" made up of up to 5 tree species.

A host group is a set of no more than 5 individual tree species that share the following characteristics:

- Host to a specific forest pest.
- Commonly found growing together in the same stands, or at least in the same survey area.

In situations where there may be more than 5 tree hosts for an agent, narrow your list down to the 5 most prevalent species and/or most important based on the tree's ecological, economic, or cultural value to the state or region in question.

It's understood that not all host tree species members in a group will be present on every damage feature where that host group is used. Do your best to balance the greater precision from creating many different host group combinations, versus the practicalities of what is detectable from the air and managing a longer quick key list.

Host group names can be up to 50 characters and when possible should spell out the components of the group. The host group member list is stored in a related table that is not accessible in the DMSM user interface. Therefore, make the host group name as self-explanatory as possible. For example "Western & Mtn. hemlock, Sitka spruce" would be a better name than "coastal conifers".

In cases where it is not possible to adequately abbreviate all the species in the group in 50 characters or less, try to be as specific as possible about the state (if applicable), the landscape setting and perhaps the damage agent. For example "LA FTC upland hardwood" could be a label for a group of susceptible hosts to forest tent caterpillar in Louisiana. Or if that same group of species is host to multiple agents, a more generic name would be appropriate (e.g. "LA upland hardwoods").

Exceptions to individual host or host group rule:

- **Abiotic damage** (Fire, Hail, Flooding, Wind, etc.) can potentially impact all tree species. In such cases, it is appropriate to use the 9998 ('all tree species') host code.
- For **Unknown** quick keys it is OK to use 299 (unknown 'conifers') or 998 ('unknown hardwoods') as the host code. For example, "unknown mortality on conifer" or "unknown defoliation on hardwoods'.

Avoid recording multiple observations for the same damage feature:

Aerial survey requires quick estimation and uses a broad brush to summarize annual forest pest damage across the nation. A review of historical aerial survey data reveals that less than 4% of all damage features include more than one observation. Adding secondary observations imply a level of precision that typically is only appropriate for ground checks. Below are two examples where, from a national reporting perspective, we ask surveyors to completely avoid or be very judicious when adding secondary observations:

- **Multiple agents contributing to the same damage type on the same host:** When using DMSM for aerial surveys, we discourage adding multiple observations for the same host within the same damage feature. If the surveyor suspects there are multiple contributing agents to the observed damage type, attribute the feature with what is considered the leading causal agent.
- **Multiple, damage types in the same damage area:** Damage types have common associates. For examples, areas of extensive topkill will often be mixed with whole tree mortality, wind damage will typically result in both branch breakage and main stem uprooting. In an area with mixed damage, the first observation should be based on the most prevalent damage type. A second damage type observation should only be recorded if of local importance and a percent affected call can be separately discerned from the air. From a national reporting perspective, only recording the most prevalent damage type is considered sufficient.

Support for overlapping damage areas features:

Prior to DMSM, post processing of aerial survey data removed overlaps to avoid double counting when generating acres-**with**-damage summaries. The percent-call measure allows for calculation of acres-**of**-damage by agent and/or host without double counting overlapping damage area features. To maintain continuity with past practice, FHAAST will continue to generate acres-**with**-damage national summaries, but also provide parallel numbers for acres-**of**-damage.

Overlaps of features with the same damage type and host are an exception to this rule. The DMSM Desktop Tools will have a utility that will allow users to identify and fix these problematic overlaps.