6.0 GROUND TRUTHING OF SITES IDENTIFIED FROM IMAGERY

As discussed in Section 5.0, areas with potentially stressed tree canopy within the study sites at the three mines were identified from the multispectral imagery. A key objective of this project was to determine if areas of distressed tree canopy could be linked to the physical dimensions of longwall mine panels. The imagery was carefully reviewed to determine if linear vegetative stress features that coincided with panel boundaries or centerlines (where surface horizontal strains or subsidence are highest, as discussed in Section 4.0) could be detected. The distressed tree canopy areas identified on the imagery were typically not linear in alignment and were not more prevalent in higher strain or subsidence areas associated with longwall mine panels.

Areas of potentially stressed tree canopy were evaluated in the field in order to determine the actual conditions of the potentially stressed tree canopy detected from the imagery. A field team consisting of Dr. Donald D. Davis, Forest Pathologist from The Pennsylvania State University, and D'Appolonia professionals performed ground truthing at areas identified as having potentially stressed tree canopy. The field effort is discussed in Section 6.5, and Dr. Davis' field notes are presented in Appendix D. An evaluation of the field data and discussion of potential causal factors for tree canopy stress observed in the field are provided in Section 8.0 of this report.

The paragraphs that follow provide a discussion of our approach to the field observations, the use of GPS to locate the stressed canopy areas in the field, property owner notification, and the quantitative and subjective evaluations performed for field sites identified from the imagery.

6.1 APPROACH TO FIELD OBSERVATIONS

6.1.1 General Approach

Ground truthing (field tree surveys) for this project, generally involved assessment of the health of a number of trees in areas of potentially stressed tree canopy identified from the imagery. Sometimes, when the identified potentially stressed tree canopy areas were large, ground truthing was performed at two or three locations within the field site.

Typically, a survey at an individual location was accomplished by evaluating trees within whatever radius was required to provide a representative number of trees.

First the overall health of canopy tree species and associated vegetation was noted. In general, the canopy comprised mainly mixed mesophytic forest species, including sugar maple, red maple and black cherry, as well as species such as black locust that were invading areas that had previously been cleared and were now reverting to forest. Ten to 20 trees, depending on the stand density, closest to the survey location center were evaluated with respect to approximate diameter, crown class, overall vigor, twig or branch dieback, crown transparency, leaf defoliation and general trunk health.

During the tree surveys within the field sites, a search for ground disturbances that might be indicative of subsidence effects was performed. Cracks in the ground were regarded as most indicative of subsidence. Observations of slope terracing, scarps and slides, and hummocks could be associated with either subsidence or natural steep slope conditions.

The following terminology for ground disturbance and its possible relationship to subsidence was used for the field reconnaissance:

- Crack – open, continuous crack of several feet resulting from strain concentration at the surface.
- Scarp – open, continuous crack with vertical displacement in response to significant strain concentration; can be associated with slides.
- Slope Terracing – Periodic terraces that develop on steep slopes in response to stress relief along a surface with highly variable overburden pressure.
- Slides – Downhill translation of the slope, associated with cracks, scarps and slope terracing in subsidence areas.
- Hummocks – Irregular ground surface features containing depressions that may result from variations in subsidence or disruption of drainage at other subsidence features.

6.1.2 Methodology for Evaluating Health of Individual Trees

6.1.2.1 Trunk Quality

The overall health of the trunk of each tree was evaluated. The methodology used was based on a modification of the Forest Service North American Maple Project, Cooperative Field Manual[19]. The trunk of each tree was examined during the visit. At that time, damage (e.g., logging wound) or decay (e.g., black locust decay) was recorded for each tree. No entry was made if the tree trunk was reasonably healthy.

6.1.2.2 Crown Quality

There are two rating systems for crown quality. The first is overall vigor rating. The overall vigor rating was performed prior to any of the specific crown evaluations and was not dependent upon any of the specific crown evaluation parameters. Specific crown evaluations were based upon branch dieback, foliage transparency and defoliation and utilized the 12-class rating system, as described below.

6.1.2.2.1 Overall Vigor Rating

Overall crown vigor was estimated in broad classes and this rating was done before the more specific crown ratings. The rating system is presented in Table 8. It should be noted that the percentages of damage used for defining vigor rating classes are independent estimates, not related to the sums of crown rating percentages.

6.1.2.2.2 Specific Crown Evaluations

A tree crown may be described as a silhouette, or single plane, outlined by the periphery of branch tips. The bottom of the crown is the lowest foliated area; it does not include the large branch stems that support the crown. For percentage estimates, large open areas within the crown are excluded; for example, openings created by the breakage of large branches. Likewise, areas on the periphery of the crown where the remnants of dead branches still remain, so called "snag" branches without small twigs, are excluded. The assumption is that the size of the crown remains relatively constant over time, but dieback, crown transparency, and discoloration are likely to change annually with varying stresses.

Twelve-class Damage Rating System This 12-class system consists of a 10-percent class rating system, except that the first class of 0 to 5 percent is subdivided into two classes. The "0" class is reserved for absolute zero, while the 5-percent class includes trace to 5 percent. The acceptable variability range shows the percentage limits because of the allowable plus or minus 1 class acceptance. For example, when the average rating of foliage transparency is 20 percent, ratings of 10 to 30 percent are considered similar when making comparisons from plot to plot.

Branch Dieback Branch dieback is used as a measure of an unhealthy condition and is defined as branch mortality that begins at the terminal portion of a limb and progresses downward. Branch dieback is assumed to be the result of stress on the tree. Short-term stresses such as excessive seed production, weather extremes, or insect defoliation may cause temporary dieback, but when the stress is removed, the trees may recover. Prolonged stresses may result in increase of dieback and eventual decline and death of the tree.

This measurement is an estimate of the proportion of the crown silhouette involved in dieback. Branches with prematurely dead terminals are considered to have dieback down to the next lower fork of equal size branch. It is assumed that large dead branches within the upper crown area died from the terminal down unless signs of girdling or breakage are present indicating that they died at the base first. Snag branches (large branches without small twigs under one-inch diameter and usually with the bark absent or with dead bark peeling away) are assumed to have died much earlier. They are not considered as part of the crown and are not included in the dieback percentage. Likewise, branch mortality at the base of the crown, assumed to be the result of shading, is not included in the measurement. The proportion of crown with crown dieback is rated using the 12-class system. The presence of one dead branch tip, at least 4 inches long, in the upper portion of the tree crown, is rated as the lowest class with dieback – the 5-percent class. When dead twigs are scattered throughout the crown, an estimate is made of the approximate proportion of foliage lost from the dead twigs, which is then recorded as the dieback percentage.

Foliage Transparency Foliage transparency is determined by estimating the amount of skylight visible through the foliated portions of branches and is averaged for the crown as a whole. It includes normal tree characteristics of foliage density as well as reduced foliage density resulting from insect damage, disease, or environmental stresses. Areas included in dieback are not rated for foliage transparency. It is assumed that an increase of foliage transparency over years indicates reduced tree vigor that eventually may lead to branch dieback. Recovery is expected from short periods of defoliation events. The standard 12-class rating system was used to estimate foliage transparency.

Defoliation Both early spring and midsummer insect defoliators may contribute to tree decline. Defoliation was estimated using the 12-class system.

6.2 LOCATION OF FIELD SITES USING GPS

As discussed in Section 5.0, areas of potentially stressed tree canopy (field sites) were identified from remote sensing imagery using the ERDAS IMAGINE software. A gridded image in State Plane coordinates (NAD83) in natural color (Figures 23 through 31) was prepared for each study site to aid in location of potentially stressed tree canopy sites in the field. The coordinates obtained from the gridded images were input to a Corvallis Microtechnology, Inc., MARCH II GPS unit. This unit was used to find field sites that could not be easily located from physical features and to confirm the locations of the ones that could. Also the unit was used to provide locations for other points of interest that were found in the field (dependent upon satellite availability and tree canopy conditions).

The accuracy of the unit in real-time applications in the field was on the order of 20 to 50 meters or better. Generally, when this proximity was reached, field sites could be identified by observing the canopy stress from the ground and comparing to the natural color images. GPS locations of areas of interest that were found in the field could be located to the same accuracy in real time or to within a few meters when corrections were downloaded at the end of the day.

The increased accuracy is possible because there are fixed stations in the Morgantown and Pittsburgh areas from which corrections can be downloaded. The fixed stations continuously record their position from the satellites and the exact positions of these stations are known. Thus, a correction can be determined for the stations, and a corresponding correction can be computed for the field unit depending upon its position relative to the station.

6.3 NOTIFICATION OF PROPERTY OWNERS

Once the study site boundaries and field sites were determined, an attempt was made to identify corresponding property owners and to contact them relative to access for ground truthing. In order to determine property ownership at the study sites, D'Appolonia personnel went to the DEP regional office in McMurray, Pennsylvania to review drawings associated with the mine permits. Mine maps showing property boundaries were generally not referenced to state plane coordinates, so the study site boundaries were transferred to the mine maps based upon common physical features.

Once the approximate property boundaries were determined relative to the study site boundaries, the property numbers associated with each study site were noted. The DEP then provided D'Appolonia with its databases of property owners for the Bailey, Blacksville Nos. 1 and 2 and Humphrey No. 7 mines. These databases indicated owners and addresses for most of the identified property numbers.

A list of owners' names and addresses was prepared, and letters were mailed out to the owners explaining that a field team would be in the area in the late August to late September timeframe and might wish to obtain access to their property. A response was received from 11 of these individuals or organizations. Although most owners responded favorably, a few responded negatively or placed conditions on access. However, only the southeast portion of study site B-1 with two areas of potentially stressed tree canopy was significantly affected. Although these two field sites were dropped from consideration, other field sites in the general vicinity were visited.

The field reconnaissance team performing the ground truthing, in general, did not encounter significant problems with owners related to access. The field team was able to evaluate most of the areas of stressed tree canopy that were detected on the multispectral imagery. A few sites could not be reached because of difficult terrain.

6.4 GENERAL OBSERVATIONS

Most of the forest stands examined during the ground truthing effort were observed to be part of the mixed mesophytic forest that is characteristic of much of southwestern Pennsylvania. The mixed mesophytic forest is dominated by a variety of hardwood tree species including sugar maple, black cherry, yellow-poplar, red maple, buckeye, and other associated species. Forest communities on south- and southwest-facing slopes, as well as on some other settings, occasionally gave way to less luxuriant oak-hickory communities. Forests in the study area ranged from early successional stands in former pastures (e.g., black locust stands) to more mature forests. Tree species observed in both the canopy and subcanopy layers were usually those species common to the mixed mesophytic forest.

One of the noteworthy observations of this survey was the relatively large number of tree species typically present in the canopy. In addition, the terrain in which the study sites were located was strongly dissected by streams and valleys, yielding many different habitats and compass aspects, which in turn often supported variation in tree species over short distances. The wide number of tree species, with their inherently different canopy characteristics, as well as the strongly dissected terrain, sometimes made it difficult to detect trends in forest abnormalities across significant distances.

Property lines, such as old fences, were evident within many of the forest stands. It is important to note that such property lines often yielded visually observable “straight lines” through the forest that were also visible on the imagery. These “lines” often were the result of forests on each side of a property boundary being managed in different ways (i.e., one side logged and the other side pastured). In addition, utility cuts were often seen on the images. However, there was no relationship between these “lines” or other linear features visible on the imagery and the underlying longwall mine panels.

In general, the forests within both undermined and non-undermined study sites were found to be healthy. Dr. Davis conducts many annual forest health surveys, especially in western Pennsylvania, and the forest conditions he observed in Greene and Washington counties were generally similar to those he has noted in Cambria, Indiana, and Westmoreland counties. The disorders that were frequently responsible for forest health problems observed in this study (i.e., locust leaf miner, elm leaf beetle, fall webworm, etc.) are often found elsewhere in the state. The effects of locust leaf miner were particularly evident throughout western Pennsylvania during the summer of 2000.

It should be noted that the focus of the ground truthing activities was on areas of vegetative distress observed in the imagery, which as indicated in Table 9, is a relatively small fraction of the total study areas. While tree health surveys were not conducted for the purpose of assessing entire study sites, the overall condition of forestlands at study sites was generally observed to be healthy.

6.5 EVALUATION OF STRESSED TREE CANOPY AREAS IDENTIFIED FROM IMAGERY

6.5.1 General

During the period from August 29 to September 28, 2000, areas of potentially stressed tree canopy identified from the multispectral scanning imagery were evaluated on the ground. Forty-eight sites with potentially stressed tree canopy were identified from the imagery. Because of problems with access permission or physical inaccessibility, some sites could not be visited. The numbers of stressed canopy areas identified at each study site and those actually visited by the field reconnaissance team are indicated in Table 6. Field sites typically ranged from 1 to 10 acres in size and represented a small portion of the total study site area, as indicated in Table 9. The area associated with an individual tree survey was approximately half an acre.

The general locations of the areas with stressed tree canopy (field sites) were determined using roadmaps, topographic maps, and gridded aerial images. The field team then navigated from nearby public roads to the field sites using the GPS unit. Once the field team reached a stressed canopy area, the area was observed for cracks, subsidence, or other evidence of mining effects on the terrain. However, it should be noted that the thick groundcover present at the time of the ground survey may have obscured such evidence.

Next, the general health of the canopy tree species and associated vegetation within the stressed canopy area were noted. The canopy generally comprised mainly mixed mesophytic forest species, including sugar maple, red maple, and black cherry, as well as species such as black locust that were invading areas that were once open fields. Oak and elm were also encountered as prominent species at some sites. The following observations were made on the canopy trees: species, approximate diameter, crown class, overall vigor, twig or branch dieback, crown transparency, leaf defoliation, and general trunk health (Section 6.1.2). Any readily observable agent causing browning or defoliation of the canopy leaves (i.e., diseases or insect feeding) at the time of the survey was recorded.

The number of trees evaluated at each field site was generally in the range of 10 to 20. At a few sites there were fewer than 10 trees. Table 10 presents a summary of the field sites, including the number of surveys at each field site, predominant tree species, other tree species, and observed canopy stress. Detailed stand and individual tree data are provided in Appendices D and E. The stand evaluations in Appendix D are presented in the order in which they were completed. At some of the larger field sites, two or three tree surveys were performed within the affected areas.

A summary of the predicted subsidence settlement and strain and subsidence effects observed in the field at the locations of potentially stressed tree canopy identified from the imagery (field sites) is presented in Table 11. The table also indicates the predominant trees and the type of stress determined from the ground truthing. The subsidence effects indicated in Table 11 were noted by D'Appolonia personnel accompanying Dr. Davis within the field site location and were not typically coincident with the tree survey plots. Some of the observations could also be from non-mining causes (steep slope instability). Where subsidence effects were detected within the tree survey plot, it is recorded in the field notes in Appendix D.

6.5.2 Bailey Mine

Sixteen areas with potentially stressed tree canopy were identified at the three study sites at the Bailey Mine. Ten potentially stressed tree canopy locations were detected at study site A-1. Study site A-1 included some public lands and a large campground whose owners allowed access. Study site A-2, which had four identified field sites, consisted primarily of land owned by Consolidation Coal Company, which was also allowed access. Two field sites were identified at study site A-3, which was located in an area of private ownership. Of the 16 sites identified from the imagery, 10 were visited by the field team.

6.5.2.1 Study Site A-1

Field sites A-1-1 and A-1-2, which were distinctly visible on the imagery, were dominated by black locust trees that had suffered leaf browning and defoliation caused by the locust leaf miner. Two tree surveys were performed at each of these field sites. Figure 36 shows three color infrared images of field sites A-1-1 and A-1-2 taken between July 2 and September 22, 2000.

Field sites A-1-4 and A-1-8 also had numerous black locust trees with leaf injury caused by the locust leaf miner. Examples of black locust trees experiencing leaf browning or defoliation by the locust leaf miner are shown in Photographs 1 to 3 (Appendix F).

Three tree surveys were performed at field site A-1-3. Field site A-1-3a in addition to black locust trees also had some dead red oaks and red maples. Field site A-1-3b also had numerous dead red oaks and red maples. Field site A-1-3c was selected immediately outside of the delineated area of stressed tree canopy on the imagery. Some subsidence cracks were observed in the vicinity. The health of trees at field site A-1-3c was similar to field sites A-1-3a and A-1-3b, with fewer dead oaks. No specific disease or insect infestation that could be associated with the deaths of red oaks and red maples was observed in the field.

Field sites A-1-4, A-1-5, and A-1-8 were dominated by black locusts or elms exhibiting leaf injury from the locust leaf miner or elm leaf beetle.

6.5.2.2 Study Site A-2

Field sites A-2-1, A-2-2 (two surveys) and A-2-3 were generally dominated by black locust and elm trees with leaf injury from infestation by the locust leaf miner and elm leaf beetle. Some black cherry and walnut trees were present at field sites A-2-2 and A-2-3 and these were affected by fall webworm. Photograph 4 shows defoliation of black cherry trees by the fall webworm.

6.5.2.3 Study Site A-3

Field site A-3-2 was dominated by elm and black locust trees whose leaves were skeletonized by the elm leaf beetle or defoliated by the locust leaf miner, respectively. Two elm trees at this site were dead and a black cherry tree was affected by fall webworm. Photographs 5 and 6 show defoliation of elm trees by the elm leaf beetle.

6.5.3 Blacksville Nos. 1 and 2 Mines

Nineteen areas with stressed tree canopy were identified on the three study sites at the two Blacksville mines. Study site B-1 had eight field sites and study sites B-2 and B-3 had six field sites each. Of the 19 sites identified from the imagery, 12 were visited by the field team. Two field sites at study site B-1 were dropped from consideration because of negative responses from the owners of the affected properties. The field team was subsequently denied access to field sites B-1-12 and B-1-13, but logging was taking place in this area and may have invalidated tree surveys anyway.

6.5.3.1 Study Site B-1

Field sites B-1-1 (two surveys) and B-1-9 were found to be dominated by black locust trees that were injured by the locust leaf miner. Overall, field site B-1-1 was probably the worst in terms of locust leaf miner injury. Figure 35 shows four color infrared images of this field site taken between July 2 and September 22, 2000. The progression of the effect of the locust leaf miner on the black locust trees is evident from the figure. Field site B-1-4 had two large red oak trees that were dead. No specific disease or insect infestation that could be associated with the deaths of red oaks was observed in the field.

6.5.3.2 Study Site B-2

Field site B-2-1 (two surveys) had some dead black locust trees as well as others with leaf browning and defoliation by the locust leaf miner. Field sites B-2-2 and B-2-6 were dominated by black locust trees that were infested by the locust leaf miner. Figure 36 shows four color infrared images of these two field sites taken between July 2 and September 22, 2000. The progression of the effect of the locust leaf miner on the black locust trees is evident from the figure. Field site B-2-2 also had some black cherry trees that were affected by lacebug. Field sites B-2-5 and B-2-8 had numerous black locust trees that were injured by the locust leaf miner.

6.5.3.3 Study Site B-3

Field sites B-3-1, B-3-2 and B-3-3 were generally dominated by black locust trees that had experienced leaf browning and defoliation by the locust leaf miner.

6.5.4 Humphrey No. 7 Mine

Twelve areas with stressed tree canopy at the three study sites at the Humphrey No. 7 Mine were identified from the imagery. Although not fully reflected in the numbers of field sites identified, the health of tree stands at the Humphrey No. 7 was generally better than at the Bailey and Blacksville Mines. Generally the insect infestations that were prevalent at the Bailey and Blacksville Mines were less evident at the Humphrey No. 7 Mine, particularly at study site D-2.

Study site D-1 had three field sites, study site D-2 had five field sites and study site D-3 had four field sites. Note that two of the four field sites associated with study site D-3 were not actually located on the site, but since this study site was a non-undermined control site, these field sites were evaluated. The field team visited 10 of the 12 field sites identified from the imagery.

6.5.4.1 Study Site D-1

Field sites D-1-1 and D-1-2 were predominantly black locust trees with leaf browning and defoliation by the locust leaf miner. Some black cherries and a black walnut affected by fall webworm were also present. Field site D-1-4 was dominated by dead and dying bigtooth aspen. The bigtooth aspen is a short-lived species and the dropout of this species is likely a natural phenomenon. No specific disease or insect infestation that could be associated with the mortality of the bigtooth aspen was observed in the field.

6.5.4.2 Study Site D-2

The canopy stress associated with field sites D-2-1, D-2-3, D-2-4 and D-2-5 was primarily due to dead red and white oaks. This is probably due to oak decline, which can result from past insect defoliation and/or drought. A discussion of the possible causes for oak decline is provided in Section 8.0.

6.5.4.3 Study Site D-3

Field site D-3-1 was dominated by black locust trees that were injured by the locust leaf miner. Some elms affected by the elm leaf beetle, as well as walnuts and black cherries affected by fall webworm, were also present. Field site D-3-2 was a relatively small area that had been heavily logged; the logging debris is believed to be the reason that the site appeared to be stressed on the imagery. Field site D-3-4 consisted primarily of dead and dying red maples. No specific disease or insect infestation that could be associated with the deaths of the red maples was observed in the field.

6.5.5 Summary of Observations

The forestlands surveyed were observed to be generally healthy. The tree surveys were conducted at locations of potentially stressed tree canopy identified in the imagery. In all, 39 tree surveys were performed at 32 field sites identified from the imagery, and an additional 3 surveys were performed on adjacent forestland.

Table 12 presents a summary of the ground truthing results for the field sites identified as potentially stressed tree canopy on the imagery. The tree species most frequently observed at the field sites was black locust, and the distress observed at the tree survey plots was attributable to insect infestation and defoliation by the locust leaf miner. This distress was observed at study sites representing both periods of mining as well as the non-undermined control study sites. At field sites where elm trees were dominant, defoliation from the elm leaf beetle was common. This distress was also observed at both undermined study sites and non-undermined control study sites.

Oak and aspen trees were the dominant tree types at a few field sites, and the primary canopy stress associated with these trees was branch dieback. These trees were only observed at field sites over mine panels, and accordingly, no comparison was possible with non-undermined control study sites. At a few field sites where maple trees were dominant, logging slash was found to be the cause of anomalies seen on the imagery. Some unrelated branch dieback of maple trees was also recorded.

As indicated in Table 11, ground disturbances that may have been related to subsidence were detected at field sites. However, there were no instances where the subsidence effects (cracks, etc.) appeared to be directly affecting the surveyed trees. The field team subsequently visited sites along mine panel boundaries, subsidence pools along Enlow Fork at the Bailey Mine, and the Lee property (where subsidence effects on trees were reported by the owner). Discussion of the field team's observations at these sites is presented in Section 7.0.

While insect infestations (particularly from the locust leaf miner) were common at most of the study sites and throughout southwestern Pennsylvania during the summer of 2000, it should be pointed out that the incidence and severity of these insect problems were generally less at the Humphrey No. 7 Mine, particularly at study site D-2. This is likely related to the composition of the forest stands. Black locust trees are more likely to be found in former pastured areas that are reverting to forest. The forest stands at the Humphrey No. 7 Mine were generally older and more established, and therefore black locust trees were less common at study sites associated with this mine.

Because the field sites visited were chosen on the basis of examination of imagery, the tree composition varied significantly among field sites, i.e., black locust trees are over represented at many field sites in proportion to their actual numbers relative to other tree species at the study sites. Also, black locust trees are not as aesthetically and economically desirable as many other species (e.g., oak, maple, sycamore, elm). Further discussion of the findings related to field observations and general conclusions are provided in Section 8.0.