

## **7.0 EVALUATION OF SUBSIDED AREAS/CORRESPONDING IMAGERY**

In addition to visiting stressed canopy areas identified from the multispectral scanning imagery (Section 6.0), the field reconnaissance team also visited areas of predicted or identified subsidence effects in order to observe possible effects on the tree canopy.

Areas with identified or predicted subsidence effects included:

- Pools along Enlow Fork within and adjacent to study site A-1
- Selected longwall panel boundaries at each mine where predicted tensional strain and thus ground disturbance would be anticipated to be most significant
- A property near study site D-1 (Lee property) identified by the owner as having experienced damage to trees following subsidence

The remote sensing imagery at these locations was further reviewed to see if the conditions found in the field could be correlated to tree canopy stress on the images.

Along a reach encompassing pools along Enlow Fork, the field reconnaissance team conducted tree surveys in an approximately 10-foot strip around the perimeters of Pools 1 to 6 and along stream segments between pools. Along longwall panel boundaries, the typical survey involved an area about 40 feet wide and 200 feet long oriented along the panel boundary. At the Lee property, a survey was conducted over an area of about 200 feet by 300 feet encompassing an observed scarp and slide.

A more subjective evaluation system was used to evaluate tree canopy conditions at the panel boundaries and Lee property. General observations including overall tree canopy health and/or lean, as well as the presence of ground cracks, slope terracing, scarps and slides, and hummocks were noted by the field reconnaissance team. Along Enlow Fork, only the vigor of trees was evaluated.

## 7.1 EVALUATION OF SUBSIDENCE POOLS ALONG ENLOW FORK

As the mining of the longwall panels beneath Enlow Fork progressed, subsidence of the streambed occurred, resulting in the creation of a series of pools along the stream course. The pool locations correspond to the interior portions of longwall panels, where vertical displacement is greatest. The areas between the pools, which displace little, correspond to the gate pillars between panels.

At pools along Enlow Fork, a strip approximately 10 feet in width extending around the perimeter of the pool was selected for evaluation. Only the overall vigor of the trees was evaluated because of the large number of trees generally found around the perimeters of pools. The overall tree vigor found at the subsidence pools (where strain should be compressive, i.e., positive) was compared to the overall vigor of trees in high tensile strain areas between pools.

The field team observed the tree health at the perimeters of six pools (referred to as Pools 1 to 6) located along Enlow Fork. The locations of the pools and the stream segments between the pools are shown on Figure 22. The possible influence of the increase in water depth on the health of the trees growing around the perimeter of the pools was evaluated. The health of the trees around the perimeter of the pools was compared to the health of trees located in the between-pool segments (referred to as Segments 1 to 6) between the pools. Only the “overall vigor” aspect of the health-rating system (Section 6.1.2.2.1) was used in the evaluation. The results of this evaluation are presented in Table 13.

Several days were allocated to evaluation of tree health along Enlow Fork (Photographs 7 and 8). Field observations indicated that the streambank soils around the pools were wetter than streambank soils at the comparable areas between pools (Photographs 9 and 10). Observations of the health of trees around the pools indicated that some tree types were affected by the increased water level and were now basically growing in the water (Photograph 11), but that other types were not adversely affected and had remained healthy (Photograph 12). Nevertheless, many trees around the pools had some degree of top dieback, regardless of location (Photograph 13). Some possible reasons for these findings are discussed in Section 7.4. However, it should be noted that for some tree

types (Table 13) there were too few individual trees growing in these areas to make meaningful comparisons.

## **7.2 EVALUATION OF LONGWALL PANEL BOUNDARY/STRAIN AREAS**

Several longwall panel boundaries and associated high strain areas were traversed by the field team. One study area was selected from each of the three mines for performing this survey. Selection of the areas to survey in the field was accomplished by reviewing the strain and subsidence estimates discussed in Section 4.0. The plots of strain and subsidence associated with the study sites (Figures 8 through 19) were reviewed, and the area with generally the largest expected magnitude of strain and subsidence was selected at each of the three mines.

These selected panel boundary areas were expected to exhibit strain cracks, scarps and slumps associated with longwall mining subsidence. It was also expected that some obvious damage to trees would be observable and that this information would provide a basis for further examination of the imagery to see if tree stress could be identified in areas where subsidence was predicted to cause the most ground disturbance.

To locate the selected areas in the field, coordinates corresponding to the areas of maximum strain were obtained from the orthorectified imagery provided by SenSyTech and input to the GPS unit. Waypoints were established along the panel boundaries so that the field team could move continuously along the boundaries. In general, the field team identified the most convenient public road to get an area and then navigated to the nearest waypoint. Once at that waypoint, they navigated to other waypoints along the panel boundary. Observations were typically made at several points along the panel boundaries. These observation points were designated as “stops” and a GPS location was obtained for the stops if conditions were favorable (i.e., sufficient satellites were available and input to the GPS unit was not blocked by tree canopy).

### **7.2.1 Study Site A-1**

Two adjacent longwall panel boundaries were selected for field reconnaissance and ground truthing at study site A-1 at the Bailey Mine. These panel boundaries were located in the general vicinity of the Four Seasons Campground, which is north of Enlow Fork near the state game lands. The panel numbers referred to in the text below were assigned by D’Appolonia during an earlier phase of the work and are shown on Figure 4.

The locations of the panel boundaries that were traversed at study site A-1 and the associated waypoints and stops are shown on Figure 37.

#### **7.2.1.1 Four Seasons Campground between Panels 7 and 8 of the Bailey Mine**

This segment of panel boundary extended northwest from Camp Resort Road and southeast toward Smokey Row Road, and was selected because of observable subsidence features (cracks). Horizontal subsidence strain (tensile) of up to  $10 \times 10^{-3}$  ft/ft was predicted along this alignment (Section 4.0). The field team first proceeded northwest from Camp Resort Road and then returned to Camp Resort Road and proceeded southeast.

##### **A-1, PB 7-8, Stop 1 (N241799, E1206343)**

Stop 1 was at a fairly flat area adjacent to the campground where there was a very large crack in the ground. It did not appear that the ground slope was steep enough for slope failure to occur. At the time of observation the surficial soils were relatively dry.

Considerable tree root breakage was noticeable along and within the crack. However, there was no noticeable associated tree mortality. The survey route followed the crack further into the forest. There were some dead chestnut oak and aspen trees observed in the area, but these trees were not located near the crack. The following leaning trees were noted:

- 1 of 11 red maples
- 1 of 2 chestnut oaks
- 1 of 5 black cherry trees

The leaning and mortality did not appear to be associated with the crack. The crowns of the affected trees were generally healthy.

##### **A-1, PB 7-8, Stop 2 (Between Waypoints 2 and 3)**

This stop encompassed an area of very large red maples, which comprised about 75 percent of the stand. The stand also included some beech, yellow-poplar and dead elms. Five separate terraces were noted in the area. Approximately 10 percent of the trees along the panel boundary at this stop (3 of 33 large red maples) were leaning. The crowns of these trees were generally healthy.

**A-1, PB 7-8, Stop 3 (Between Waypoints 2 and 3)**

This stop was on a very steep, wet bank on the east side of a stream. A few leaning trees were observed at the very top of a hillside, but nowhere else. The crowns of these trees were generally healthy.

**A-1, PB 7-8, Stop 4 (N 241656, E 1206636)**

This stop was on the west side of a stream, approximately 300 feet uphill from the stream. At this location, there was a crack about 2 feet deep by 6 inches wide. The following leaning trees were noted:

- 2 of 6 black cherry trees
- 0 of 1 chestnut oak
- 1 of 4 red maples
- 0 of 5 sugar maples
- 0 of 1 black walnut
- 1 of 1 red oak

However, the crowns of these trees, even along the crack, were generally healthy.

**A-1, PB 7-8, Stop 5 (Between Waypoints 1 and 2)**

This area was a thicket of 2-inch-diameter beech trees. Because of the thick ground cover and small size of the trees, no survey was performed and the team proceeded to the next stop.

**A-1, PB 7-8, Stop 6 (Between Waypoints 1 and 2)**

This stop was across a small stream on a hillside facing back towards starting point. There was evidence of ground disturbance related to subsidence in the area. Leaning trees were noted on:

- 3 of 21 maples
- 1 of 11 beech trees

However, the crowns of these trees were generally healthy.

**A-1, PB 7-8, Stop 7 (Between Waypoints 2 and 3)**

This stop was also across the small stream, but further up the hillside facing back towards starting point. There were no observed subsidence features observed in the area.

Leaning trees were noted on:

- 1 of 21 maples
- 1 of 11 beech trees

The crowns of these trees were generally healthy.

**7.2.1.2 State Game Lands between Panels 6 and 7 of the Bailey Mine**

This segment of panel boundary extended between Four Seasons Road and Smokey Row Road to the southeast. There was considerable terracing observed along the panel boundary, but there were no readily apparent scarps. Horizontal subsidence strain (tensile) of up to  $2 \times 10^{-3}$  ft/ft was predicted for this segment (Section 4.0).

**A-1, PB 6-7, Stop 1 (N 240109, E 1208048)**

This stop was within a white oak/beech forest (a rather unusual species mix) on a bench near a gas well road on a very steep hillside. Leaning trees included:

- 2 of 7 red oaks
- 1 of 5 white oaks
- 0 of 4 beech trees

This was a mature, healthy stand on a steep hillside, with relatively dry soil conditions.

**A-1, PB 6-7, Stop 2 (N 241860, E 1203940)**

This stop was on a bench further up the hillside. Leaning trees included:

- 0 of 10 maples
- 0 of 3 white oaks
- 0 of 1 red oak,
- 1 of 11 beech trees

This was a mature, healthy stand on a steep hillside with dry soil conditions.

**A-1, PB 6-7, Stop 3 (N 239473, E 1209591)**

This stop was on the southeast end panel boundary. This area was very hummocky and many young trees had curved stems possibly as a result of previous soil movement.

Leaning trees included:

- 1 of 11 maples
- 0 of 1 black cherry trees

Overall, perhaps 5 percent of the trees had a slight lean, and 10 percent had a slightly more pronounced lean. However, this would not be unusual for a normal forest on a steep hillside. Tree crowns were generally healthy.

**A-1, PB 6-7, Stop 4 (N240943, E 1206015)**

This stop was in a very pronounced bowl in which about 5 percent of the trees were leaning. However, this would not be unusual for a normal forest on a steep hillside.

Leaning trees included:

- 3 of 14 maples
- 0 of 1 elm
- 1 of 1 red oak
- 1 of 1 white oak

In general, tree crowns were observed to be healthy.

**7.2.2 Study Site B-1**

A longwall panel boundary was selected at study site B-1 at the Blacksville Mine. Horizontal subsidence strain (tensile) of up to  $7 \times 10^{-3}$  ft/ft was predicted along this alignment. The location of the panel boundary that was traversed at study site B-1 and the associated stop are shown on Figure 38. The panel boundary passes through field site B-1-1. No evidence of subsidence-related slides, scarps or ground settlement was observed by the field reconnaissance team.

**B-1, Stop 1 (N 157799, E 1258122)**

This site was accessed from a road off of Tom's Run Road (SR 3009). The area associated with the stop was doubly drained with an excellent stand of cove hardwoods.

Most of the trees were very healthy, and had healthy crowns. There were some slightly leaning trees observed on:

- 1 of 10 maples
- 0 of 2 buckeyes
- 0 of 2 hickories
- 0 of 1 Ostrya
- 1 of 15 yellow poplars

The observed tree lean was typical for steep slopes.

### **7.2.3 Study Site D-2**

The boundary between longwall panels 12 and 13 at study site D-2 at the Humphrey No. 7 Mine was selected for field study. Horizontal subsidence strain (tensile) of up to  $6 \times 10^{-3}$  ft/ft was predicted along this alignment (Section 4.0). The panel numbers referred to were assigned by D'Appolonia during an earlier phase of the project and are shown on Figure 6. The location of the panel boundary that was traversed at study site D-2 and the associated stops are shown in plan on Figure 39.

This area had multiple surface interruptions, as evidenced by many hummocks and terraces. Approximately every 10 to 15 feet on a line perpendicular to the mine panel boundary there was a terrace with the more level areas having wetter soils than the slopes. Some trees were observed to be leaning uphill, and some downhill. Isolated trees were growing at a 45-degree angle to the vertical. In spite of these disturbances, the tree crowns were observed to be generally healthy. Most of the damage to trees along the panel boundaries was observed to occur where the original ground slope was steepest.

#### **D-2, Stop 1 (N 166550, E 1300350)**

Stop 1 was located just east of SR 2005 at the western end of the panel boundary segment that was traversed. In this area there was a substantial subsidence slide with an associated scarp. Severe tree lean along the scarp was noted on:

- 1 of 4 maples
- 1 of 9 basswoods
- 0 of 2 hickories
- 4 of 19 red maples

- 0 of 3 elms
- 0 of 1 Ostrya
- 0 of 3 red oaks
- 0 of 1 black cherry
- 0 of 2 yellow poplars
- 0 of 1 sassafras
- 0 of 1 white oak
- 0 of 1 serviceberry

There was root breakage on some trees affected by the scarp, but crowns of these trees appeared to be generally healthy.

### **D-2, Stop 2 (N 166073, E 1302411)**

Stop 2 was located just west of T580 at the eastern end of the panel boundary, as shown on Figure 36. Severe tree lean along the scarp was noted on:

- 3 of 20 maples
- 0 of 2 red oaks
- 0 of 3 Ostryas
- 1 of 3 hickories
- 0 of 5 white oaks
- 2 of 11 elms
- 0 of 1 yellow-poplar
- 0 of 2 sassafras
- 0 of 2 hackberries

Severe root damage was observed to some trees along the scarp, but the crowns of the affected trees appeared to be healthy.

### **7.3 EVALUATION OF LEE PROPERTY**

Field evaluation of the Lee Property was performed after the owner responded to the property owner notification letter from D'Appolonia. The owner indicated that he owned a property over the Humphrey No. 7 Mine that had experienced substantial subsidence and had affected the trees on the property. Although the trees affected were not currently commercially valuable, it was decided to evaluate this property in order to observe the extent of tree damage on the ground and to see if the ground observations could be detected on the imagery. The location of the Lee property is shown on Figure 40. It is adjacent to the eastern end of a longwall panel and would have experienced subsidence in

the first half of 1995. Predicted horizontal subsidence strain (tensile) in this area is estimated to be 3 to 4 x 10<sup>-3</sup> ft/ft (Section 4.0).

The property in question is an old field undergoing early, normal succession from an open field to a young forest. The major plant species observed on the property were goldenrod and weeds with some small young sassafras and ash trees. A scarp and slide were observed. The magnitude of vertical displacement was estimated to be 3 to 4 feet (Photograph 14), and the area appeared to be wet with new watercourses and very hummocky in nature. The degree of slope was moderate for the relatively large amount of soil movement noted (observed at several points within the subsided area). There were many terraces indicating the possibility of multiple soil slides. The moving soil appeared to be sliding over the old plant surface (Photograph 15), which may have contributed to the relatively large amount of movement.

In general, there was root breakage (Photograph 16) around the scarp at the edge of the area, and root masses were generally sliding downhill. Many trees within the area were leaning (Photograph 17) or had fallen (Photograph 18). Many ash trees within the area were dead or had top dieback (Photograph 19), apparently due either to root movement or to wet soils.

#### **7.4 SUMMARY OF FIELD OBSERVATIONS IN SUBSIDED AREAS**

##### **7.4.1 Enlow Fork Pools**

Differences in tree health among tree species around the perimeters of pools and similar species along the stream segments between pools appeared to be related to the moisture tolerance of the species. Some typical examples are described in the following paragraphs.

Sycamore trees had approximately the same percentage of trees in good health (combined “good” and “excellent” crown ratings) around the perimeters of the pools, as compared to those trees growing along the streambank between pools. The increased water content of the soil around the pools had no noticeable effect on the general crown health of sycamore. This can be explained, at least partially, by the fact that sycamore trees are often found in wet bottomland conditions and have evolved to tolerate wet sites such as those occurring around the subsidence pools.

Black locust, boxelder, and elm also had approximately the same percentages of healthy trees around the pools as between the pools. The black locust is considered to be a cosmopolitan species that is able to grow and tolerate a wide variety of conditions, including wet areas. Likewise, elm trees can tolerate wet areas. In fact, elm (i.e., American elm) is often considered to be an associate of sycamore, growing on similar moist sites. Boxelder is one of the most aggressive species in the maple family and can maintain itself on many unfavorable sites. These three species apparently can tolerate a relatively wide range of soil moisture conditions, including the more wet conditions in the vicinity of the subsidence pools.

In contrast, black walnut trees had healthier crowns along the stream banks of the segments between pools, as compared to those growing around the perimeters of the pools. Although black walnut trees can grow on moist soils, this species favors deep and well-drained (not wet) soils. In fact, black walnut trees are very sensitive to soil conditions. However, relatively few (n=34) black walnut trees were found in the study area along Enlow Fork.

Maples in the wetter conditions around the perimeters of the pools had poorer health than maples in areas between pools. Although black, red, and sugar maples were grouped together, most of the trees encountered and rated were sugar maples. Sugar maple trees prefer well-drained sites and were not fully healthy around the pools. Many of the maples along Enlow Fork also had ice damage to their trunks, as well as old beaver damage and associated decay from both types of injuries.

#### **7.4.2 Longwall Mine Panel Boundaries**

In many areas there was observed damage to tree roots resulting from the effects of mining subsidence. Also, some trees were observed to be leaning. However, there was in general relatively little crown damage associated with the observed subsidence effects, whether located at recently undermined sites or at sites undermined more than 10 years ago. No significant tree mortality resulting from subsidence effects along the panel boundaries was observed by the field team.

### **7.4.3 Lee Property**

Damage to tree roots resulting from a scarp and slide in the area of reported subsidence on the Lee property, possibly in association with wet ground conditions, was observed to have resulted in mortality or top dieback in a young stand of trees. Ash in the area surrounding the slide at the Lee property, but still within the influence of the mine panel, also exhibited ash dieback, but the dieback was perhaps twice as severe within the slide area. Many healthy ash seedlings were observed within the subsidence area.

## **7.5 EVALUATION OF IMAGERY AT AREAS OF KNOWN SUBSIDENCE**

### **7.5.1 Enlow Fork Pools**

The pools created by subsidence along Enlow Fork are shown on Figure 22, which presents color infrared and night thermal images of the study area. Review of these images, and other imagery such as natural color and NDVI, did not indicate conditions around the pools that were distinguishable from conditions nearby. It should be noted that the water surface at the pools is in a color similar to distressed tree canopy on the color infrared imagery. This increases the difficulty of detection.

Also, the most frequently observed unhealthy tree condition around the pools was top dieback. Dieback manifests itself as fewer leaves on a given tree, whereas an insect infestation such as locust leaf miner often results in brown leaves and thus shows up more clearly on the imagery. The difficulty of detection is likely also attributable to the fact that only a small percentage of trees along the perimeter of the pools (i.e., black walnut and maples) exhibited detectable health impacts, as compared to the segments between pools.

### **7.5.2 Longwall Mine Panel Boundaries**

The longwall mine panel boundaries that were evaluated by the field reconnaissance team are shown on Figures 37 through 39, which show natural color images of study sites A-1, B-1 and D-2, respectively. The natural color, color infrared, NDVI and thermal imagery was reviewed. However, tree canopy conditions at stops where field surveys were conducted could not be distinguished from tree canopy conditions in the surrounding area, consistent with the generally healthy canopy conditions observed on the ground along the panel boundaries.

### **7.5.3 Lee Property**

An enlargement of the Lee property area on natural color and color infrared images is shown on Figure 40. Evidence of tree canopy stress was difficult to detect on the natural color image, but some scattered small greenish areas (perhaps individual trees) on the color infrared imagery may be related to the observed tree distress and mortality. The conditions observed in the field were generally tree mortality and dieback of successional, young ash and sassafras trees. Dieback in areas of less dense canopy is difficult to identify on the imagery.