

Structural failure profile: Blue gum (*Eucalyptus globulus*)

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EACH YEAR, THE STRUCTURAL FAILURE of trees in urban and forested recreation areas results in personal injuries and property damage. A key objective of a tree management program is to reduce the potential for failure to the extent possible. One important element of failure reduction strategies is to prevent or mitigate conditions that may lead to failure, such as pruning branches weakened by wood decay, cabling or bracing, and avoiding root damage.

All tree species do not fail in similar ways, however. Some are prone to fail as a result of weak architecture, such as codominant stems. Others have a greater propensity to fail because they develop large end-weights on branches — exceeding the load tolerance of the wood. Knowing the particular failure patterns or traits of species can help tree managers identify key defects that may lead to failure (Fig. 1).

By collecting detailed information following the failure of a tree, data can be compiled and then used to develop structural failure profiles for a species. Such a profile has been developed here for Tasmanian blue gum (*Eucalyptus globulus*) using data from the California Tree Failure Report Program (CTFRP). Arborists and foresters can use this information to develop structural management strategies for blue gum. The development of this profile was commissioned by the Britton Fund of the Western Chapter of the International Society of Arboriculture.

Figure 1. Property damage is not uncommon when trees fail. Here, a large blue gum caused considerable damage to this house. Photo: T. Larson



Blue gum distribution

Blue gum is native to Tasmania and Australia, but was introduced to California in the 1800s and has become naturalized. Originally planted in windbreaks and for timber, it is now commonly found in parks and often planted as a landscape tree. It can be found in the Central Valley and along the coast, from Humboldt County to San Diego County.

General statistics

There are a total of 307 reports in the database for blue gum, the majority of which are for branch (134) and root (128) failures. The remaining 43 reports are for trunk failures.

Most of the failures (73%) occurred on trees that were between 26 and 100 years old (Table 1). Reports came from 24 counties, but the majority (110 reports) are from San Francisco. Blue gum failures occur more commonly in the winter months, with 58% of failures reported from November to February.

Most failed trees were found in a group (67%), in high use areas (36%), and in parks (48%). The most common defect for all failures was heavy lateral limbs, observed in 29% of reports, followed by dense crowns and multiple trunks (12% each).

A. BRANCH FAILURE

Branch failure was reported in 134 cases, or 44% of total reports.

Branch failure location

The majority of branches failed at some distance along their length (62%) (Fig. 2). Failures along the branch

Table 1.
General statistics for all failure types.

Variable	Mean
Age	65 years
Height	81 feet
DBH	44 inches
Crown spread	44 feet



Figure 2. Most blue gum branch failures occur along the branch, i.e., rather than at the attachment. A very long branch failed many feet from the attachment (arrow) on this blue gum.

Table 2. Defects reported associated with branch failures.

Defect	Frequency
Heavy lateral limbs	54%
Dense crown	10%
Multiple branches	9%

Table 3. Cross-sectional area of branch with decay and failure occurrence.

Cross-sectional area with decay	Frequency
< 25%	54%
26-50%	29%
51-75%	11%
> 76%	6%

cross sectional area of decay was given in 35 reports, where 54% had less than 25% of the area decayed (Table 3).

Wind and branch failures

Although more failures occurred in low wind conditions where wind speed did not exceed 5 miles an hour (38%), the failures were distributed fairly evenly across low,

Knowing the particular failure patterns or traits of species can help tree managers identify key defects that may lead to failure.

mostly occurred within 6' (40%), with diameter of the break highest in the 9-12 inch range (28%). The majority of trees with branch failures were between 76 and 100 years old (36%).

The main structural defects observed in trees with failed branches are consistent with the defects across all failure types – heavy lateral limbs, dense crowns, and multiple trunks were observed in 54%, 10%, and 9% of cases respectively, (Table 2). Multiple branches originating at the same point were also associated with branch failure.

Decay and branch failures

Decay was reported in 45% of the branch failure cases. The

Table 4. Wind speed and branch failure.

Wind speed	Frequency of occurrence
Low wind (<5 mph)	38%
Moderate wind (5-25 mph)	31%
High wind (>25 mph)	31%
Crown spread	44 feet

Table 5. Defects reported associated with trunk failures.

Defect	Frequency
Multiple trunks/codominant stems	33%
Failed portion dead	13%
Embedded bark	10%

moderate, and high wind speeds (Table 4).

Precipitation and branch failures

The majority of branch failures occur during dry conditions (61%), while 39% occur under any precipitation condition.

B. TRUNK FAILURE

Trunk failures occurred in 14% of reported failures (Table 5). Most occurred at the ground level (51%), while 49% occurred at a distance above the soil surface. Trunk diameter at the point of failure ranged from 7 to 99 inches, but the majority (61%) were between 7 and 24 inches in diameter.

Figure 3. Trunk failures occurred less frequently than branch or root failures. Codominant stems is the most commonly reported defect. Photo: C. Rippey



Table 6. Cross-sectional area of trunk with decay and failure occurrence.

Cross-sectional area with decay	Frequency
< 25%	15%
26-50%	30%
51-75%	35%
> 76%	20%

Table 7. Wind speed and trunk failure.

Wind speed	Frequency of occurrence
Low wind (<5 mph)	16%
Moderate wind (5-25 mph)	47%
High wind (>25 mph)	37%

The primary defect associated with trunk failure is multiple trunks or codominant stems, observed in 33% of the cases (Fig. 3). Dead portions of the tree and embedded bark were also associated with trunk failure, seen in 13% and 10% of cases, respectively.

Decay and trunk failure

Decay was reported in 23% of trunk failures. The cross sectional area of decay in the trunk varied across the entire range of 0-100% area decayed, with over 41% of trees with 26-75% cross-sectional area decayed (Table 6).

Precipitation and trunk failures

The majority (56%) of trunk failures occurred during dry conditions.

Wind and trunk failures

Trunk failures most commonly occurred during moderate wind conditions between 5-25 mph (47%), followed by failure at high wind (37%) and low wind (16%). (Table 7).

C. ROOT FAILURE

Root failure is the second most common failure type, with 128 reports (42% of total). Trees experiencing root failure ranged from 2-133 years old, with the majority (57%) aged 26-75.

Figure 4. Decay was associated with 62% of root failures in blue gum. Other contributing factors included dense crown and kinked and girdling roots. Photo: J. Scow



Table 8. Defects reported associated with root failures.

Defect	Frequency
Dense crown	16%
Kinked/girdling root	14%
Leaning trunk	11%

Defects and root failures

The most common defects were dense crowns (16%), kinked or girdling roots (14%), and leaning trunks (11%). (Table 8). 16% of failures were reported to be defect-free.

Decay and root failures

Root decay was observed in 62% of failures (Fig. 4). The cross sectional area of decay was reported in 64 cases, with the majority (42%) decayed between 26-50% of the area (Table 9).

Wind and root failures

The majority (71%) of root failures occurred during high wind conditions, while 18% and 17% of failures occurred under moderate and low wind speeds, respectively (Table 10).

Precipitation and root failures

Unlike branch and trunk failures where the majority of failures occurred during dry conditions, most of the trees with root failures (71%) were reported to have failed under precipitation conditions.

Summary of key findings

Branch and root failures collectively comprise 85% of blue gum reports.

Although more branch failures occurred at low wind speeds, nearly equal numbers of failures occurred during low, moderate and high wind speeds. Trunk failures were most common at moderate wind speeds (47%), while root

Table 9. Cross-sectional area of root with decay and failure occurrence.

Cross-sectional area with decay	Frequency
< 25%	27%
26-50%	42%
51-75%	16%
> 76%	16%

Table 10. Wind speed and root failure.

Wind speed	Frequency of occurrence
Low wind (<5 mph)	17%
Moderate wind (5-25 mph)	18%
High wind (>25 mph)	71%

failures were most common under high wind conditions (71%).

The majority of branch (61%) and trunk (56%) failures occurred during dry conditions, while 71% of root failures occurred when there was some form of precipitation.

Decay was associated with 45%, 23%, and 62% of branch, trunk, and root failures, respectively.

The majority of the decayed portion of the cross-sectional area at the point of failure was under 25% for branch failures (54%), between 26-75% for trunk failures (65%), and between 26-50% for root failures (42%).

Branch failures were more common along the length of the branch than at the attachments (62% of cases).

Heavy lateral limbs are the primary defect associated with branch failures, occurring in 54% of cases, followed by dense crowns and multiple branches.

Trunk failures were more common at the ground level but occurred at a similar frequency to failures at a height above the surface (51% and 49% respectively). Most failed trunks were between 7" - 24" in diameter at the point of failure.

The most common defects associated with trunk failures were multiple trunks or codominant stems, dead portions at the point of failure, and embedded bark.

The most common defects associated with root failures are dense crowns, and kinked or girdling roots.

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