

Structural failure profile: Monterey Cypress (*Hesperocyparis macrocarpa*)

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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.

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 Monterey cypress (*Hesperocyparis macrocarpa*, formerly *Cupressus macrocarpa*) using data from the California Tree Failure Report Program (CTFRP). Arborists and foresters can use this information to develop structural management strategies for coast live oak. The development of this profile was commissioned by the Britton Fund of the Western Chapter of ISA.

Monterey cypress distribution

A California native tree, Monterey cypress occurs on the Pacific Coast in two groves, at Cypress Point (Pebble Beach) and Point Lobos (Carmel). It is a commonly planted landscape tree in California, performing best near the coast (Fig. 1). Monterey cypress is included in the California Native Plant Society's Inventory of Rare and Endangered Plants.

General statistics

Tree failures can be divided into 3 groups based on the part that fails: branch, trunk, and root. Of the 463 reports for Monterey cypress, 222 are branch failures (48%), 82 trunk failures (18%), and 159 root failures (34%). The majority of failures (80%) occur on trees ranging from 26 to 100 years old (Table 1).

Although failures were reported in 12 counties, 72% were from San Francisco, with the majority (67%) occurring during the months of November, December, and January.

Failed trees occurred principally in groups (69%) in medium to high use areas (78%). Aside from decay, key defects across all types include heavy lateral limbs (27%), multiple trunks/codominant stems (15%), and dense crown (11%).

A. BRANCH FAILURE

Branch failure was the principal type of failure for Monterey cypress: 222 cases or 48% of all failures.

Branch failure location

Branch failures can occur either at the point of attachment to the trunk or along the branch (Fig. 2). The majority of failures occurred along the branch for Monterey cypress (69%), while the remainder occurred at the attachment. For failures along the branch, distance from the point of attachment ranged from 1 to 12 feet for 72% of cases. Diameter of failed branches was highest (63%) in the 5- to 12-inch diameter range.

Defects and branch failures

Heavy lateral limbs (end weight), multiple branches/codominant stems, and dense crown were the leading

Table 1.
General statistics for all failure types.

Variable	Mean
Age	66 years
Height	68 feet
DBH	40 inches
Crown spread	42 feet

Table 2. Defects reported associated with branch failures.

Defect	Frequency
Heavy lateral limbs	54%
Multiple branches/codominant stems	15%
Dense crown	9%
None	4%



Figure 1. (Left) Although native stands are very limited in California, Monterey cypress is commonly planted in parks, golf courses, and urban landscapes.

Figure 2. (Center) Many branch failures of Monterey cypress occur along the branch (arrow), commonly associated with heavy end weights and dense crowns.

Figure 3. (Right) The majority of branch failures are sound wood failures.

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structural defects associated with branch failures (Table 2). Acting in concert with these defects, additional loads caused by wind and rain contribute substantially to branch failures.

Decay and branch failures

No decay was reported in the majority (74%) of branch failures (Fig. 3). Ostensibly, these failures occur along the branch and are associated with heavy end-weights. Assessments of the cross-sectional area with decay are given in 45 reports. Of these, the majority of cases (60%) indicate that less than 25% of the cross-sectional area was decayed (Table 3).

Wind and branch failures

The majority of Monterey cypress branch failures (50%) occur during high wind conditions, while 34% occur during moderate wind, and 16% during low wind (Table 4).

Precipitation and branch failures

Most branch failures (78%) occurred during wet condi-

tions (rain, fog or mist). The remainder occurred during dry conditions.

B. TRUNK FAILURE

Of the 3 failure types, trunk failure was least frequently reported, amounting to 18% of all reports. Most failures occurred above ground level (79%), with the remainder occurring at ground level (Fig. 4). Trunk diameter at the

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

Cross-sectional area with decay	Frequency
< 25%	59%
26-50%	22%
51-76%	17%
> 76%	2%



Figure 4. (Left) Most trunk failures of Monterey cypress occur above the ground line, typically associated with high wind and rainfall.

Figure 5. (Right) Multiple stems is a key structural defect leading to trunk failure in Monterey cypress.

break ranged from 6 to 54 inches, with the majority (63%) in the 13- to 30-inch diameter range. Key defects associated with trunk failures include multiple stems/codominant stems (Fig. 5), dense crown, and cracks/splits (Table 5).

Decay and trunk failure

Decay was reported to be a contributing factor in 63% of all trunk failures. Assessments of the cross-sectional area

Table 6. Cross-sectional area of trunk with decay and failure occurrence.	
Cross-sectional area with decay	Frequency
< 25%	41%
26-50%	37%
51-76%	17%
> 76%	5%

with decay were given in 46 reports. The cross-sectional area (CSA) of the trunk affected by decay varied considerably from less than 25% to greater than 76% (Table 6). Over 78% of failures occurred when decay was less than 50% of the cross-sectional area (Fig. 6)

Precipitation and trunk failures

Most trunk failures (75%) occurred during rainfall events,

Table 4. Wind speed and branch failure.	
Wind Speed	Frequency of occurrence
Low wind (<5 mph)	16%
Moderate wind (5-25 mph)	34%
High wind (>25 mph)	50%

Table 5. Defects reported to be associated with trunk failures.	
Defect	Frequency
Multiple stems/codominant stems	47%
Dense crown	10%
Cracks/splits	10%

Table 7. Wind speed and trunk failure.	
Wind Speed	Frequency of occurrence
Low wind (<5 mph)	11%
Moderate wind (5-25 mph)	28%
High wind (>25 mph)	61%



Figure 6. (Left) Decay is associated with 63% of trunk failures, but less than half of the cross-sectional area is decayed in 78% of cases.

Figure 7. (Center) Root failures are the second most frequent failure type for Monterey cypress. High wind and rain commonly contribute to root failures.

Figure 8. (Right) Dense crown and kinked/girdling roots frequently contribute to root failures.

while the remainder (25%) occurred when conditions were dry.

Wind and trunk failures

As with branch failures, the majority of trunk failures occurred under high wind conditions (61%). During moderate and low wind conditions, 28% and 11% of failures were reported to have occurred (Table 7).

C. ROOT FAILURE

Following branch failure, root failure was the second most common failure type reported for Monterey cypress (Fig. 7). Failed trees ranged in age from less than 10 years to more than 200 years, with the majority (79%) being 26 to 100 years old.

Defects and root failures

No defects were noted in 25% of all root failures for Monterey cypress. Where defects were noted, dense crown and kinked/girdling roots were the most common type (Table 8) (Fig. 8).

Decay and root failures

Decay was associated with 39% of root failures. The majority of failures (61%) occurred with no signs of decay noted. For roots with decay, the cross-sectional area (CSA) of

decay ranged from less than 25% to more than 76%, with the majority (69%) having less than 50% (Table 9).

Wind and root failures

High winds (> 25 mph) contributed to 79% of root failures (Table 10). Few cases occurred during low wind conditions (4%), while 17% occurred during moderate wind conditions.

Figure 9. Rainfall and high winds contribute to many root failures of Monterey cypress.



Table 8. Structural defects associated with root failures.	
Defect	Frequency
Dense crown	19%
Kinked/girdling roots	19%
One-sided crown	9%
Multiple trunks	9%

Table 9. Cross-sectional area of root with decay and frequency of occurrence.	
Cross-sectional area with decay	Frequency
< 25%	30%
26-50%	39%
51-75%	18%
> 76%	13%

Table 10. Wind and root failure	
Wind Speed	Frequency
Low (<5 mph)	4%
Moderate (5-25 mph)	17%
High (>25 mph)	79%

Precipitation and root failures

The majority of root failure cases (87%) in Monterey cypress are associated with rainfall events (Fig. 9). Few failures (17%) occur when conditions are dry.

Summary of key findings:

Branch failure (48%) was the most common type of failure for Monterey cypress, followed by root (34%) and trunk (18%).

High wind was reported in 79% of root failures, 61% of trunk failures, and 50% of branch failures. Precipitation was reported to contribute to 87% of root failures, 75% of trunk failures, and 78% of branch failures.

Although decay was associated with 63% of trunk failures, no decay was reported in 74% of branch failures and 61% root failures. Less than 50% of the cross-sectional area was noted to be decayed in 81% of branch failures, 78% of trunk failures, and 69% of root failures.

Branch failures occur most frequently along the branch (69%), and less frequently at the attachment (31%). Heavy lateral limbs, multiple branches/codominant stems, and dense crown are key defects associated with branch failure.

Most trunk failures occur above the ground line (79%) in the 13- to 30-inch DBH size class. Key defects associated with trunk failures include multiple stems/codominant stems, dense crown, and cracks/splits

No defects were reported for many root failures (61%). When defects were noted, dense crown and kinked/girdling roots were most common.

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