

# Structural Failure Profile: Monterey Cypress (*Hesperocyparis macrocarpa*)

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# 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 Monterey cypress. The development of this profile was commissioned by the Britton Fund of the Western Chapter of the International Society of Arboriculture.

### *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 commonly planted landscape tree in California, performing best near the coastline (Fig. 1). Monterey cypress is included in the California Native Plant Society's *Inventary 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

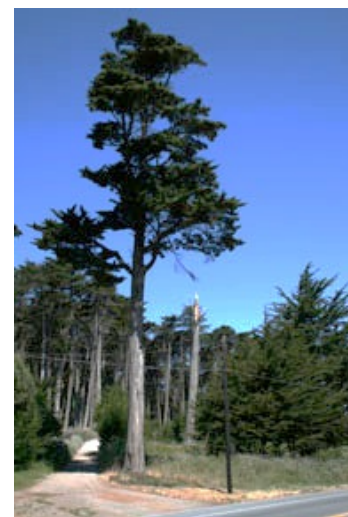


Fig. 1. Although native stands are very limited in California, Monterey cypress is commonly planted in parks, golf courses, and urban landscapes.

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San Francisco, with the majority (67%) occurring during the months of November, December, and January.

Table 1. General statistics for all failure types.

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

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-ft for 72% of cases. Diameter of failed branches was highest (63%) in the 5- to 12-inch diameter range.



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

#### Defects and branch failures

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

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Table 2. Defects reported associated with branch failures.

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

### *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 the less than 25% of the cross-sectional area was decayed (Table 3).



Fig. 3. The majority of branch failures are sound wood failures.

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%

### *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).

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%

### *Precipitation and branch failures*

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Most branch failures (78%) occurred during wet conditions (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 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.)



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

Table 5. Defects reported to be associated with trunk failures.

Defect	Frequency
Multiple stems/codominant stems	47%
Dense crown	10%
Cracks/splits	10%

### *Decay and trunk failure*

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



Fig. 5. Multiple stems is a key structural defect leading to trunk failure in Monterey cypress.

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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%

### *Precipitation and trunk failures*

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



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

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%

## 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).



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

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Table 8. Structural defects associated with root failures.

Defect	Frequency
Dense crown	19%
Kinked/girdling roots	19%
One-sided crown	9%
Multiple trunks	9%

### *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).

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



Fig. 8. Dense crown and kinked/girdling roots frequently contribute to root failures.

Cross-sectional area with decay	Frequency
< 25%	30%
26-50%	39%
51-75%	18%
> 76%	13%

### *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.

Table 10. Wind and root failure

Wind Speed	Frequency
Low (<5 mph)	4%
Moderate (5-25 mph)	17%
High (>25 mph)	79%

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### *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.



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

### **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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