The California Tree Failure Report Program: An Overview

by L. R. Costello and A. M. Berry

Abstract. The California Tree Failure Report Program was established in 1987 to collect quantitative information about urban tree failures. This information is used to develop "failure profiles" for genera and species to more accurately assess failure probability in standing trees. Over 100 tree care professionals are cooperating in this effort by systematically inspecting fallen trees, or tree parts, and reporting results for entry into a data-base program. After 3 years, we have collected 500 reports and are beginning to identify failure occurrences and trends for certain taxa.

Tree failures occur wherever trees exist. Trunk breaks, branch breaks, or blowovers happen in forests, wildland areas, and urban areas. When failures occur in urban areas, personal injury and/or property damage may result. Trees standing next to highways, school yards, picnic grounds, homes, or other "targets", are of particular concern. To reduce tree failures on public and private property, systematic inspection and hazard mitigation programs have been developed (1, 5). Such programs have been successful in identifying imminent hazards: trees with obvious structural weaknesses which require prompt attention, such as trunk cracks, crotch splits, or leans with root movement. In these cases, the problem is clear, and mitigation is immediate. In cases where structural defects are not pronounced, or where immediate action is not required, then hazard assessments attempt to estimate the probability of failure. Probability of failure estimates are based on a combination of factors, which include categories based on tree structure, tree environment, and previous tree care (1). Structural factors may include decay, trunk defects, branch attachment, and canopy balance. Environmental factors include weather conditions (wind speeds, direction, and gustiness), irrigation effects, and restrictions to root development (hardpans, retaining walls, etc.). These and other factors need to be considered for each tree evaluated.

It is difficult in many cases to judge the relative importance of structural or environmental factors in contributing to a failure. We have very little factual information on failure patterns that might exist for particular species, or as a result of environmental conditions or human activities. For example, in California, *Eucalyptus* is considered to be prone to branch failure. To accurately assess failure probability, however, it is important to know whether particular *Eucalyptus* species are more prone to branch failure than others. Do the failures occur during calm as well as windy conditions? Do certain pruning practices, such as heading or lion tailing, lead to branch failure in these species? Are there correlations between where failures occur (along the branch or at the point of attachment) and weather conditions? These and many more questions may be raised during an assessment for *Eucalyptus*, or any other genera and species. Little information is available that addresses these questions, however. Most of our information is based on observations, which are generally not documented, and are not always reliable. Accurate, quantitative information regarding factors that contribute to urban tree failure has not been compiled.

Failure information has been collected for thousands of trees in forested recreation sites (2, 3, 4). Paine (4) developed tables of tree damage potential based on his data. However, since these studies were limited to forest species in recreation sites, the data have limited application to urban tree assessments.

Recognizing the need for accurate failure data for urban trees, the California Tree Failure Report Program (CTFRP) was established in 1987. The objective of the program was to collect reliable information regarding tree failures shortly after they occur, and to use this information to develop "failure profiles" for urban trees. This information could then be used by tree managers to more accurately assess hazard potential. Essentially it is a "postmortem" program; it recognizes that there is something to be learned after each failure, and that the information can be used to assess potential for future failures. The following discussion describes the CTFRP program, summarizes data collected to date, and reviews the benefits of establishing such a program.

Materials and Logistics

A failure report form was developed (Fig. 1) to enable participating arborists to collect detailed information about individual tree failures. The form is a comprehensive checklist which serves as a permanent record of each occurrence. In addition to basic items such as tree name, age, size, and location, six general categories of information are requested: 1) details of failure, 2) structural defects, 3) decay or injury, 4) maintenance history, 5) soil and root conditions, and 6) weather. Statistical methods can be applied to data collected for each of these categories so that the type of failure and circumstances which led to the failure can be characterized.

The form is designed so that up to three contributing factors within any category can be reported, and these factors can be prioritized in order of importance. For example, under *Tree Structural Defects*, if a dense crown, one-sidedness, and girdling roots contributed to a blowover, then numbers 3, 5, and 12 would be entered in the spaces to the left of the defects list. If it appeared that girdling roots were the most important contributing factor, followed by one-sidedness, and dense crown, then numbers would be entered in the order 12, 5, and 3, from top to bottom. If a category does not apply or other circumstances contributed to the failure, then 13 (none) or 14 (other) would be entered. This approach accommodates a database that allows for meaningful statistical comparisons.

The reports are intended to be detailed and do require some time for completion. Once an arborist is familiar with the format and items in each category, however, reports can be completed in 10 to 15 minutes, or less. We consider it necessary to include any possible contributing factors in the checklist so that we do not limit the database.

Many of the common factors involved in failures are included in the checklist, but we recognize that a checklist does not always allow for a complete analysis of a failure. For example, if a tree uproots because an adjacent tree has restricted its root development (anchorage) on one side, then the failure would not be adequately described by the checklist. Space is provided on the second page for a short narrative describing the failure (Fig. 2). Information regarding property damage, personal injuries, costs for clean-up, and additional comments is also requested on page 2. This is an opportunity to report information that is not associated with every failure, but is of interest when evaluating failure impacts.

Cooperators

A network of CTFRP cooperators was established to report on failures in their areas. Invitations were extended to qualified tree care professionals to participate in the program. Each was supplied with forms and stamped return-envelopes. To assure quality control in the information reported, all cooperators attended a CTFRP training class. They were instructed on how the form was to be completed, and what was meant by certain terms, such as "lion-tailing" or "fungal sporophores." It was vital that a "common thinking" was established among cooperators in regard to the information requested. Cooperators were advised that incomplete or inaccurate information would seriously diminish the value of the program. Completed reports were not accepted from individuals who had not been trained.

Completed reports were sent to the Environmental Horticulture Department at the University of California, Davis, where a database program has been designed using dBase IV (Ashton-Tate) to facilitate entry and analysis of CTFRP data. Reports are received, data are entered for each category on the form, and originals are filed. Photographs, slides, newspaper clippings, or other supportive materials enclosed with the report are also kept on file.

Current Project Status

As of December, 1990, 500 CTFRP reports have been filed, with over a hundred cooperators participating state-wide, in twenty-three counties. Approximately two-thirds of the reports have been

Figure 1

Date of Report ______________________

CALIFORNIA TREE FAILURE REPORT

University of California, Davis, CA 95616

Tree Genus ______________________
Species ______________________
Cultivar (if known) ______________________
Common name ______________________
Approx. age _____yrs., Height _____ft., DBH _____in.
Crown spread _____

Tree Owner ______________________
Site: County ______________________
City ______________________
Address/Park ______________________
____ Site category (choose one): 1-Residential 2-Street 3-Park 4-School 5-Highway 6-Parking lot 7-Mall 8-Other

DETAILS OF TREE FAILURE

(1) Date of failure: ______________ (Mo/Day/Yr)
(2) Time of failure: ______________ (Hr/AM or PM)
____ (3) Location of failure on tree (choose one)
1-Trunk: ___ft. above ground, ___inches break diam.
2-Branch: ___ft. from attachment, ___in. break diam.
3-Root (including uprooting)
____ (4) Site use (choose one) (Explain on p.2 Additional Info)
1-Undeveloped
2-Low use (intermittent vehicles and/or people)
3-Medium use (permanent structures, intermittent vehicles and/or people)
4-High use (permanent structures, frequent vehicles and/or people)
____ (5) Stand type: 1-Natural 2-Planted 3-Mixed
____ (6) Tree occurring 1-Alone 2-In a group 3-Altered stand

TREE STRUCTURAL DEFECTS

____ (7) Choose up to three, in the order of importance
____ ____
1-Failed portion dead
2-Multiple trunks/stems
3-Dense crown
4-Heavy lateral limbs
5-Uneven branch distribution: onesidedness
6-Uneven branch distribution: top-heavy
7-Branches at same point
8-Embedded bark in crotch
9-Crook or sweep
10-Leaning trunk
11-Cracks or splits (describe p. 2)
12-Kinked or girdling roots
13-None apparent
14-Other (describe p. 2)

TREE DECAY OR INJURY

____ (8) Type of decay at failure location (choose one)
1-Root rot 2-Heart rot 3-Sap rot
4-Heart rot and sap rot 5-No decay noted
____ (9) Extent of decay or cavity (% cross-sectional area) (For root failure estimate % structural roots decayed)
1- 0-25% 2- 25-50% 3- 50-75% 4- 75-100% 5-Unknown
____ (10) Fungal sporophores or conks found near failure location?
1-Yes 2-No
____ (11) Other injury at failure location (Choose up to three, in order of importance)
____ ____
1-Mechanical 2-Lightning 3-Insect 4-Animal
5-Chemical 6-Vehicle 7-Fire 8-None 9-Other (p. 2)
____ (12) Other injury, entire tree (same choices as 11) (Choose up to three, in order of importance)
____ ____

MAINTENANCE HISTORY

____ (13) Pruning at failure location (Choose up to three)
____ ____
1-Heading cuts - moderate amount
2-Heading cuts - severe
3-Thinning cuts (or drop-crotching)
4-Lion-tailing
5-Flush cuts
6-Root pruning
7-No pruning
8-Other (p. 2)
____ (14) Pruning on entire tree (Same choices as 13) (Choose up to three)
____ ____
____ (15) Other maintenance (Choose up to two)
____
1-Cable/hardware failure
2-Staking/props
3-Girdling wire, rope, etc.
4-Cavity treatment
5-Injections
6-None

SOIL AND ROOT CONDITIONS AT SITE

____ (16) Restricted roots (Choose up to two)
____
1-Raised planter or bed
2-Container or boxed tree
3-Root barriers
4-Root cutting
5-Not applicable
6-Other (p. 2)
____ (17) Irrigation
1-None
2-Less than once per mo.
3-More than once per mo.
4-More than 3X per mo.
____ (18) Ground cover under tree (Choose up to two)
____
1-Bare soil
2-Mulch
3-Turf
4-Native cover
5-Herbaceous plants
6-Shrubs
7-Mixed planting
8-Paving
9-Other
____ (19) Soil in tree vicinity (Choose one)
1-Good condition
2-Compacted
3-Saturated
4-Dry
5-Shallow
6-Other (p. 2)
____ (20) Site topography/soil changes (Choose up to two)
____
1-Excavation-depth ____ft.
2-Grade change - cut
3-Grade change - fill
4-Slope erosion
5-Streambank erosion
6-Not applicable

WEATHER AT TIME OF FAILURE

____ (21) Wind speed: 1-Low (less than 5 mph) 2-Moderate (2-25 mph) 3-High (25+ mph)
____ (22) Wind 1-Gusty 2-Steady
____ (23) Wind in prevailing direction for season? 1-Yes 2-No
____ (24) If branch failure, was wind direction 1-Parallel to OR 2-At right angles to branch direction? (Omit if no wind)
(25) Temperature: _______ degrees F
____ (26) Precipitation (Choose one)
1-Rain 2-Snow 3-Ice 4-Fog or mist 5-None

sent in from arborists in the greater San Francisco area, where we have held the most training sessions. As we have begun to report findings, interest in the program has increased. There is now substantial interest from the San Diego and greater Los Angeles urban areas. We hope to extend our training workshops to include this group soon.

Some Highlights of the Survey

Three categories of data have early interest to us: 1) the location of the failure on the tree, whether trunk, branch or roots (Location of Failure); 2) structural problems associated with the failure (Tree Structural Defects); and 3) the wind speed at the time of failure—low to no wind; medium wind, 5-25 mph; high wind >25 mph.

For the database as a whole, location of failure was fairly evenly distributed among the trunk, branch, and root categories, with more branch failures (42%) than trunk (30%) or root (28%) failures reported. Root failures occurred mostly (67%) in high winds, while branch failures occurred in all wind conditions. Heavy lateral limbs were by far the most common defect in branch failures (75 of 201 branch failures, or 37%), and were the most often-reported structural defect overall. Certain structural defects were associated frequently with high wind conditions (such as embedded bark in branch crotch, branches at the same point, or multiple stems). Failures associated with heavy lateral limbs were reported in all wind conditions, however.

Trunk branch, and root failures have been reported for at least 62 different tree genera. Of these, reports on five genera have been the most numerous: *Quercus* (110), *Pinus* (76), *Eucalyptus* (70), *Ulmus* (33), and *Cupressus* (30). Reports on oaks represent about 20% of the total reports filed. Since there are many native oaks in our city landscapes, as well as pines and *Eucalyptus*, these data do not necessarily indicate an inherent propensity to failure for these particular genera. We do not yet have estimates of the relative abundance of genera and number of individuals of a species in survey locations.

The high number of reports for these five genera will allow us to look more closely at them, to compare them to the database as a whole and to see whether we can identify a "failure profile" for a particular genus. It is interesting to note for example that 55% of all failures reported for oaks happened in low or no wind conditions. By contrast, only 15% of all failures reported for *Eucalyptus* happened during low or no wind. Branch failures were the most frequent type of failure in *Eucalyptus* (>50%); branch and trunk failures were both fairly common in oaks (about 38% each). These and other data suggest that failure profiles can be assembled, which will provide useful information for understanding tree failure, perhaps helping to reduce tree hazards.

Specific Requests

In addition to the above data summaries, specific requests regarding failure types have been received. For example, one cooperator was interested in failures associated with girdling or kinked roots. At the time, approximately 4% of all failures reported were due to girdling roots. Of these, 53 per cent were pines over 30 feet in height. This is of interest because pines are a much smaller fraction (15%) of the total number of reports. Indications are, therefore, that girdling roots may occur more frequently in pines than other species, and they could be an important factor to consider in stability assessments.

Feedback Mechanisms

Three ways of returning information to cooperators have been established: a newsletter, an annual meeting, and personal requests. The newsletter *Breaktime* is published in the spring and fall of each year. CTFRP report totals, data summaries, interesting features, and program status reports help cooperators stay informed. It is essential that a close link be established with cooperators, and the newsletter has served this purpose.

In addition to the newsletter, an annual meeting is held during the winter months. This is an opportunity for cooperators to meet one another and discuss issues relevant to tree failures. A full day program includes presentations on subjects such as wood decay or sudden branch drop, as well as data summaries and analysis.

Cooperators also receive information regard-

Figure 2

I. Briefly, in your own words, why did this tree failure occur?

II. Results of this tree failure (i.e., property damage, personal injury, etc.):

III. Damage estimate (costs for clean-up; indicate other costs if known):

IV. Additional information and comments:

Person reporting ______________________________ Date ______________

Title ____________________ Agency ______________________________

Address ______________________________

____

Telephone (   ) ______________

Please complete this report to the fullest extent, include any available photographs, and send to your local Cooperative Extension office or to TREE FAILURE REPORT, Dept. of Environmental Horticulture, University of California, Davis, CA 95616. Direct any questions to your local Cooperative Extension offfice or to Alison Berry (916) 752-0130. Thank you.

The information in this report will remain confidential, and will only be used to develop statistical and general information about tree failures by species and type of failure.

If additional copies are needed, please photocopy or request from UC Davis.

A.M. Berry
L.R. Costello
R.W. Harris

Revised 3/18/90
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ing particular species or types of failures via personal requests. As noted previously, a request was received for cases where kinked or girdling roots were noted as structural defects. In another case, an arborist was interested in failures associated with severe heading cuts. Entering the appropriate information into the computer, a printout of all heading-cut related failures was generated. This included information on species, age, size, and conditions at the time of failure. In some cases, there may be little or no data relevant to the request. Lack of information can be useful when assessing the frequency of particular types of failures in certain species. For example, we observe very few branch failures in London plane tree (*Platanus acerifolia*). In checking the database, we find no reports of this failure in this species. Of course we cannot conclude that *P. acerifolia* does not have branch failures, but it is an indication that the frequency of failure may be low.

These three feedback mechanisms have all served to establish a vital link in the informational loop from data collection to data application.

Other Benefits

Aside from collecting data to make probability of failure estimates, other benefits have been realized. Certainly, public safety has been improved. Cooperators report that because of their systematic inspection of failed trees, they now look more closely at remaining trees for conditions similar to the failure. Such inspections are the cornerstone of hazard assessment programs and are well recognized to reduce failure potential (5). Tree preservation has also been seen as a benefit. Recognizing and mitigating structural weaknesses results in a longer life for many trees.

Perhaps one of the greatest benefits has been professional improvement. By providing a thorough mechanism for inspecting tree failures, cooperators have gained a greater understanding of tree structure and function. Determining how a tree fails helps one understand how it is put together. Repeatedly we hear cooperators say the CTFRP form has motivated them to inspect failures more closely than before. Previously, tree clean-up was the first priority after a failure. In some cases, failures could be ignored completely. Now, cooperators inspect and ask questions about the cause of failures. This invariably leads to a greater understanding of trees and therefore improves professionalism.

Application

The CTFR Program can easily be adapted for use in other states and countries. The form and database program may need to be amended for local conditions, but basic elements of the data collection network would remain the same. Certainly it is important to have as many well qualified cooperators as possible, but a small group of active individuals can accomplish a lot.

Acknowledgments. The authors gratefully acknowledge the ISA Research Trust for supporting this project. Further support was received from the University of California Opportunity Grant Program, the Landscape Supervisor's Forum, and a private donation from a consulting arborist. Special recognition is extended to the many cooperators who have contributed their time and talents to this effort.

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Environmental Horticulture Advisor
University of California Cooperative Extension
625 Miramontes, Suite 200
Half Moon Bay, CA 94019
and
Assistant Professor
Environmental Horticulture Department
University of California
Davis, CA 95616

Résumé. Le Programme d'information sur les faiblesses des arbres de la Californie (California Tree Failure Report Program) était créé en 1987 afin de recueillir de l'information quantitative sur les faiblesses des arbres urbains. Cette information est employée pour développer des "profils de faiblesses" pour les genres et les espèces afin d'établir plus fidèlement une probabilité de faiblesse dans les arbres sur pied. Plus de 100 professionnels de l'entretien des arbres ont coopéré dans cet effort en inspectant systématiquement les arbres qui ont chuté, ou les portions d'arbres, et en notant les résultats pour entrée dans un programme de bases de données. Aprè trois ans, nous avons recueilli 500 compte-rendus et avons commencé à identifier les fréquences et les tendances de faiblesses pour certains taxons.

Zusammenfassung: The California Tree Failure Report Program wurde 1987 gegründet um quantitativische Information über städtisches Baumsterben zu sammeln. Diese Information wird angewendet um Baumsterben für Art und Gattung im Profil darzustellen und weiterhin Baumsterben-Wahrscheinlichkeit unter den stehenden Bäumen genauer zu schätzen. Mehr als 100 professionelle Baumpfleger machen bei dieser Bemühung mit, und nach systematischen Untersuchungen von gefallenen Bäumen und Baumteilen werden die Resultate in den Computer gespeichert. Nach drei Jahren haben wir 500 Berichte gesammelt und wir beginnen Baumsterben Vorfälle und Trends für bestimmte Taxus zu identifizieren.

ABSTRACTS

McCREARY, D.D. 1990. **Blue oaks withstand drought**. California Agriculture 44(2): 15-17.

In mid-August 1987, many oak trees in California began turning brown and dropping their leaves. Most observers felt the reason for the trees changing color so early was drought. This is consistent with knowledge of tree physiology. A study was undertaken to identify; some of the effects of drought on blue oak trees. The initial analysis examined whether or not there were significant relationships between the degree of defoliation and subsequent growth and development, including survival, acorn production, and leaf-out date. All 200 trees survived both years' defoliations and leafed out the following springs. Defoliated trees tended to leaf out earlier than those that remained green. The results of this study suggest that summer defoliation of blue oaks from drought has little short-term impact on growth or survival. California's blue oaks are apparently well adapted to withstand the adverse effects of periodic droughts.

BOOTH, D.C., T. SMILEY and B.R. FRAEDRICH. 1990. **New technology from IPM programs**. Arbor Age 10(2): 12-14,16.

IPM provides early detection and spot treatment of insects, mites, diseases, and cultural problems. The major goal of a tree-and-landscape IPM program is improved plant care with reduced chemical usage. The following new technology represents developments currently available to the arborist to help meet this goal: Horticultural Spray Oils Insecticidal Soap, Natural Insecticides, Biological Control, Pyrethroids, Plant Disease Detection, Slow-Release Nitrogen Fertilizers, pH Testing, Foliar Nutrient Analysis and Soil Aeration Machines. New developments will continue to refine and improve the IPM technology available to the arborist. The challenge for IPM programs in the 1990s will be to improve our ability to detect problems and treat them with the least possible environmental impact.