

# Inventory of Commercial Hardwoods in the High Sierra<sup>1</sup>

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**Abstract:** A hardwood resources assessment was completed for the Sierra Economic Development District in the north central Sierra Nevada. The assessment included the development of a tree grading system for the major hardwood species in the area, an inventory of the hardwood resources, and recommendations for hardwood management. Hardwood volumes of total wood available for utilization per acre were found to be low for stands classified in the Blue oak-Interior live oak association, moderate in the Black oak - Canyon live oak association, and high in the Madrone association. The volumes by species and grade reveals that madrone stands produce a relatively high amount of merchantable timber, while black oak stands produce moderate levels.

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The purpose of this study was to determine the potential for a hardwood industry in the north central Sierra. The study area is defined as the counties of Amador, El Dorado, Nevada, Placer, and Sierra. In the study area, it is estimated that 548,000 acres are covered in hardwood woodlands or commercial timberland (Bolsinger, 1986). The study involved assessing the hardwood resource base to determine the quantity and quality by species of the product in the region.

The study's further objective was to develop management techniques to enhance and perpetuate the species that were found to be commercially abundant in order to establish a viable hardwood industry.

The species sampled in this study include: bigleaf maple (*Acer macrophyllum* Pursh), Pacific madrone (*Arbutus menziesii* Pursh), tanoak (*Lithocarpus densiflorus* (Hook. & Am.) Rehd.), canyon live oak (*Quercus chrysolepis* Liebm.), blue oak (*Quercus douglasii* Hook. & Am.), Oregon white oak (*Quercus garryana* Dougl.), California black oak (*Quercus kelloggii* Newb.), interior live oak (*Quercus wislizenii* A. DC.). White alder (*Alnus rhombifolia* Bong.) occurs in the area but represents less than one percent of the volume. It was included in the inventory, but not in the tree grading estimates, since there are already well established log grading rules for the genus.

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## BACKGROUND

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California hardwood stumpage prices are low compared to their eastern counterparts. The low prices are a result of a perception that the hardwoods consist of limited supplies, small log sizes, and inferior quality. A recently completed assessment of this resource, however, has produced data which indicates that those perceptions may be false. Hardwood forests cover 9.6 million acres in California. The total volume of these trees are estimated to exceed 18 billion cubic feet. Of the hardwood trees over 29 inches in diameter, California has 19 percent of the nation's growing stock (Bolsinger 1986).

New information about hardwood distribution, the volume of standing timber, and the potential for producing different kinds of wood products, has recently encouraged resource specialists to consider greater use of California's hardwood resources (Passof 1986). Methods for determining the wood quality of local hardwood tree species is greatly needed.

A local tree grading system allows the landowner to determine the value of his hardwood resources, while providing a means to compare those values with other sources of lumber; and it improves the precision of a timber appraisal by allowing a value to be placed on hardwood trees based upon timber quality. This process will also aid future land managers, loggers and lumber processors to identify new sources of timber (Rast, Sonderman and Hilt 1986).

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## PROBLEM STATEMENT

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The annual harvest of California's softwood resources amount to over 95 percent of its annual growing stock (Bolsinger, 1986). As a result, any additional demand for more wood products will severely strain that resource. It is possible that future needs for more wood products will be met by harvesting hardwoods rather than softwoods. Total volume of the commercial hardwood in California is estimated to be 25 billion board feet. The annual harvest amounts to less than 5 percent of the state's annual growth.

Information about the quality of California's hardwoods is meager. Data on quality as well as the quantity of high quality hardwoods should be obtained prior to the development of the hardwood resource. A constraint in evaluating California's

hardwood resources was the lack of a tree grading system or rules to define a high quality hardwood tree (Rast and others 1986).

## Objectives

The primary goal was to determine the commercial potential of hardwood resources on private land. A second goal was to determine the quality of the hardwood resource by developing a tree grading system.

In order to assess the hardwood resource base and develop management prescriptions, the following objectives were formulated:

- 1) To complete a broadly based inventory of the hardwood woodland areas in the counties of the High Sierra Resource Conservation and Development Area. Information on stand type and volume by log grade, crown density, and acreage was obtained in stands having a canopy cover of 33 pct or more;
- 2) To develop management recommendations for the major hardwood associations found in the study area;
- 3) To develop a tree grading system that will account for the high degree of variability in hardwood stands in the study area.

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## HARDWOOD RESOURCES OF THE STUDY AREA

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In the study area, most stands of pure hardwoods are found below the 5000 foot level. As a result, the study area included only the western half of Amador, El Dorado, Placer and Nevada. An extensive field reconnaissance confirmed that very few hardwoods were found above 5000' and therefore, no inventory was attempted in Sierra county.

The remaining four counties are characterized by long, hot summers and cool winters with light snow below 5000' elevation. The topography is often steep, rugged and dissected by deep river drainages. Hardwood species are abundant on the warmer, drier south and western aspects. Hardwood stands with high crown densities are found in the transition zone between the mountains and the foothills. Most of the hardwoods can be found within the 580 foot to 4,700 foot elevation range (McDonald, Minore and Atzet 1983).

Three broad hardwood types, based on the Wildlife Habitat Rating Program are found in this area (Mayer and Laudenslayer 1988). They are the Valley-Foothill Hardwood type, the Montane Hardwood type and the Montane Hardwood-Conifer type.

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## HARDWOOD TIMBERLAND INVENTORY

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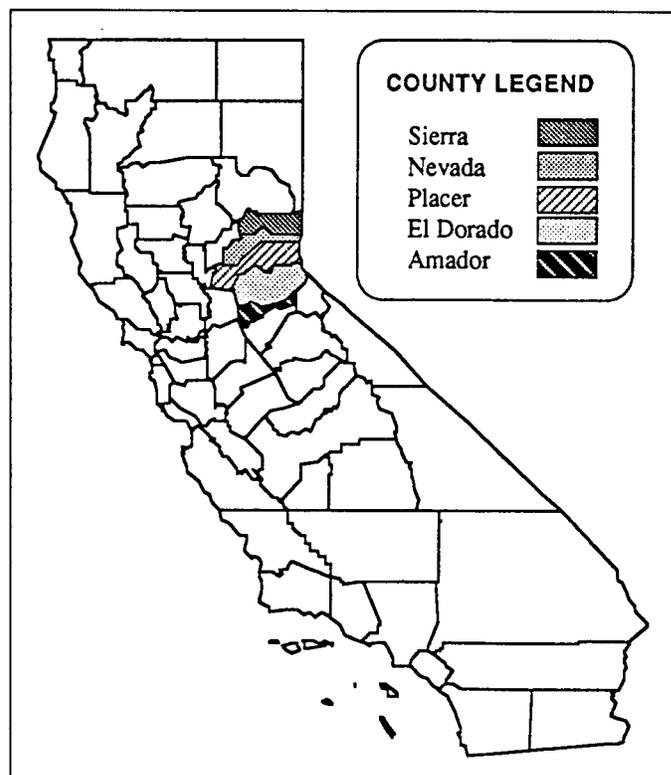
### *Development of California Hardwood Tree Grading System*

The local grading system used to evaluate the quality of standing hardwood timber was modified from eastern hardwood tree grading rules (USDA-Forest Service) to accommodate California's hardwoods. This modified system was simpler to follow, with final specifications based upon tree measurements collected during the study's reconnaissance cruise.

The grading section minimum length was reduced to an eight foot section compared to 12 feet used in the east, because local wood processors indicated that shorter lengths could be used if the log diameter was large enough.

In order to simplify the grading rules, single minimum diameters and minimum lengths of clear cuttings for the specifications in each of the tree grade categories were used.

Because of the greater variability found within the Sierra hardwood populations, the specifications for dbh and the number of defect indicators found on the grading section were given wider ranges (table 1).



**Figure 1**—Five county study area of the Sierra Economic Development District in California.

**Table 1**—Hardwood tree grading rules developed and used in this study.

Grade Factor	Tree Grade 1	Tree Grade 2	Tree Grade 3
Length of grading section (ft.)	16	Best 12	Best 8
Minimum dib top of grading zone (in.)	14	12	10
Dbh, minimum (in.)	16	14	12
Total number of defect indicators (best of three faces)	6	9	12
Maximum number of defect indicators per face (best of three faces)	2	3	4
Minimum length of clear face (best of three faces)	8	6	4

The length of the grading zone for all grades is 16 feet. Defect indicators include: Sweep (>8 inches in 16-foot length); Crook; Rot and Seams; Knots>0.5-inch diameter; Overgrowth; Overgrowths with epicormic branches; Fire scars.

Field procedure for tree grading is as follows (figure 2):

- 1) Measure the diameter-breast-height (dbh) to the nearest inch;
- 2) Establish the location of all defect indicators on the surface of the 16 foot butt log, and then locate the best 8 foot section;
- 3) Estimate the diameter-inside-bark (dib) at the top of the 16 foot grading zone to the nearest inch; and
- 4) Estimate the amount of defect by percentage in the 8 foot section.

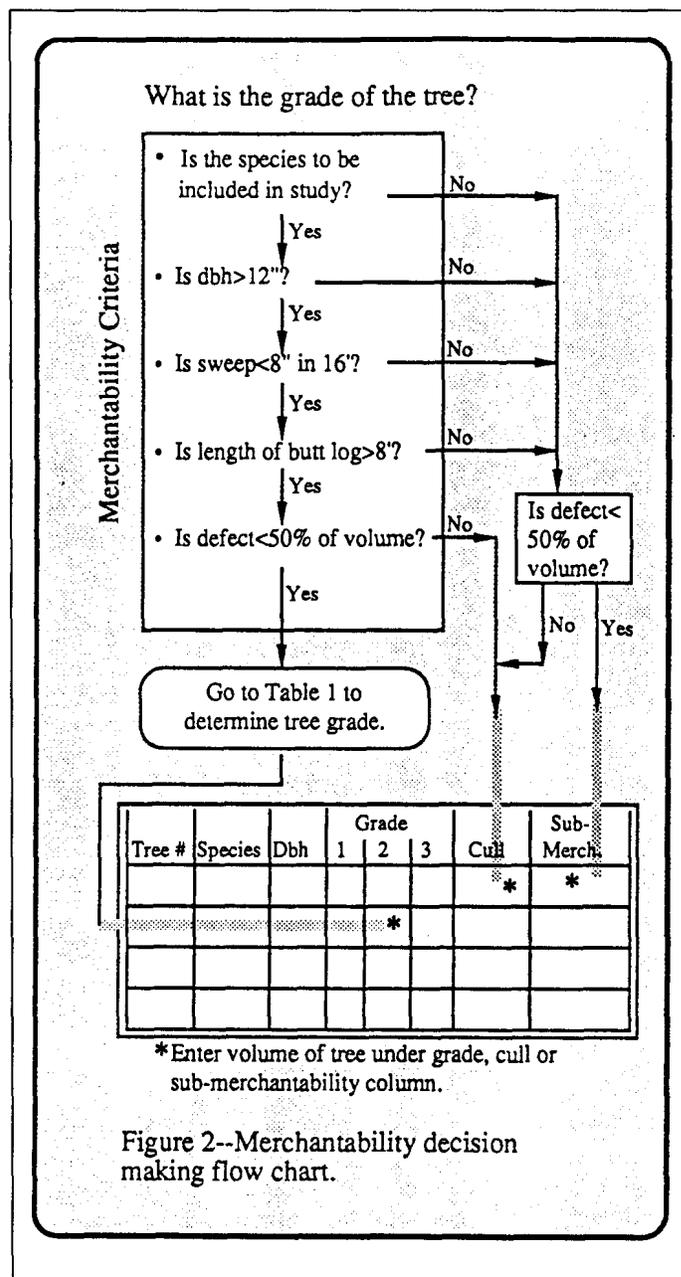
The grade of the 8 foot section becomes the grade for the tree, unless the grade can be improved by using a 12 or 16 foot section (figures 3-4) (McCaskill and Pillsbury 1990).

## The Hardwood Resource Assessment Methodology

Because of the extensive size of the study area (five counties), a cluster-plot inventory was designed to insure that enough sampling units of the population were included. A total of 56 cluster plots were selected and plotted on county maps. Plots were located in stands greater than 5 acres so that a four plot cluster could be installed with a 50 foot buffer zone.

For inventory purposes, the sample stands were stratified by crown closure density classes so that stands with the greatest commercial potential (crown density classes > 33 pct) would be included in the study. Maps developed by the Forest & Rangeland Resources Assessment Program (FRRAP; Calif. Dept. Forestry & Fire Protection) were used to stratify hardwood stands.

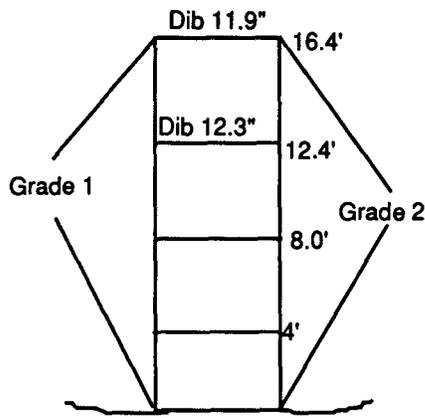
Cluster plots were established to collect detailed information about individual trees, plot area descriptors, tree associated vegetation, and the quality of standing timber. Each cluster consisted of four plots, arranged in a “+” shape, with each of the legs being oriented in a cardinal direction.



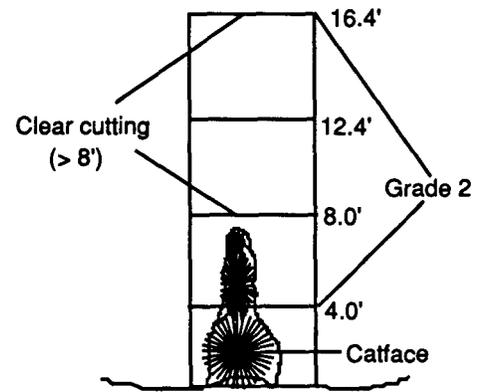
**Figure 2**—Merchantability decision making flow chart.

To begin, a reconnaissance cruise of the different strata (density classes) was conducted so that a sampling system could be designed that met statistically acceptable standards and was representative of the population.

Variable plot sampling was used to select the sample trees. A prism with a ten square foot basal area factor was used for the inventory based on the results of the reconnaissance cruise. Volume data was collected at one of the four plots in the cluster. The volume measurement plot was selected randomly by the use of a die. Information on diameter at breast height, height, vigor, and crown closure was recorded. Tree volume was calculated from this data.



**Figure 3**—Relationship between dib (diameter inside bark) and tree grade. The dib at 16 feet 4 inches above the stump is not large enough for grade 1. However, at 12 feet, the dib meets grade 2 requirements.



**Figure 4**—Effect of catface on tree grade. Because of catface, the surface is grade 2 and not grade 1. If total cull is less than 50 percent, retain the tree grade at 2.

## Volume per Acre Determination

The following steps were used to process and summarize the field data:

- 1) The plot sheets were arranged in numerical sequence and the information was tallied by species, diameter class, and grade.
- 2) The gross volume by species and log grade was calculated using the volume equations for California hardwoods (McDonald 1983) and (Pillsbury and Kirkley 1984);
- 3) The cruise data was summarized showing gross volumes by species and log grade;
- 4) The cruise data was grouped into hardwood associations for analysis;
- 5) The diameter class information was tallied and used to determine the average diameters per species;
- 6) The determination of cubic foot and Scribner board foot volumes per acre from variable plot sampling methodology was calculated.

## RESULTS

Based on field observations and data analysis, three hardwood associations were developed; that is, certain hardwood species were found to have similar habitats, ranges, and common grading qualities. The three hardwood species associations are the Blue Oak - Interior Live Oak Association, the Black Oak - Canyon Live Oak Association, and the Madrone Association. The Association names were based on those hardwood species that were found most often growing in the same stands (table 2).

**Table 2**—Species composition in percent by species association.

Species	Blue oak- Interior live oak	Black oak- Canyon live oak	Madrone
Canyon live oak	7.0	24.0	7.0
Interior live oak	42.0	6.0	
Black oak	1.0	66.0	1.0
Blue oak	47.0	1.5	
Madrone		2.0	75.0
Tanoak	3.0		8.0
Oregon white oak			7.0
White alder		0.5	0.5
Big leaf maple			1.5
	100.0	100.0	100.0

## The Hardwood Resource Assessment

The hardwood sample included 2,117 trees measured on 56 cluster-plots. This was an average of 9.5 trees per plot. Black oak had the highest tree count with 694 trees tallied. Interior live oak, canyon live oak, and blue oak had similar sample sizes; with 399, 339, 377 trees measured, respectively. Madrone, which was found to occupy only a small proportion of the study area had 268 trees measured.

Approximately 539 trees were graded for form and defect. The merchantability of each tree was determined by diameter size and log length.

**Table 3**—The percentage of each species by grade.

Species	Grade 1	Grade 2	Grade 3	Cull	Sub-Merch.
Canyon live oak	3.2	12.9	16.1	19.4	48.4
Interior live oak	0.0	2.9	1.0	11.5	84.6
Black oak	7.5	19.9	18.4	13.9	40.3
Blue oak	0.0	3.2	13.8	7.4	75.6
Madrone	12.3	18.4	24.6	10.8	33.9

## Hardwood Volumes

The cubic foot and board foot volumes/acre were calculated for the three hardwood associations (table 4a). All cubic foot volumes/acre estimates fell within the ranges tabulated in the statewide assessment (Bolsinger 1986) for the five major hardwood species of this study. The Madrone Association volumes were twice as high as Black Oak - Canyon Live Oak Association and over four times higher than Blue Oak - Interior Live Oak Association. The inventory also produced results showing the existence of large diameter trees that compared favorable with the statewide data.

Madrone produced the greatest amount of merchantable volume (grades 1-3), over 8000 board feet per acre (table 5). Black oak had about 2500 board feet per acre. Common characteristics that might account for the relatively high merchantable volumes per acre pure stands and average diameters larger than the minimum required for merchantable grading. Blue oak, interior live oak, and canyon live oak had very low volumes in merchantable timber, reflecting their smaller diameters and poorer forms.

This method can be used to assist the landowner in appraising hardwood resources.

## Summary of Results

The hardwood timber inventory concentrated on the higher density stands. The tree grading focused on those hardwood species with the greatest potential for wood utilization. From the work on the hardwood inventory and evaluating applying the local tree grading rules, the research yielded these results:

1) Three unique hardwood species associations were identified based on common range, habitat and grading characteristics;

2) A local hardwood tree grading system for evaluating California woodlands in the Sierras was developed;

3) An assessment was completed of the hardwood volume per acre in the Sierra Economic Development District area by species, associations, and tree grade.

## CONCLUSION AND RECOMMENDATIONS

The purpose of conducting a feasibility study of the hardwood resource base of the area was to determine if there was sufficient quantity and quality to develop a value-added hardwood industry. It was found that a viable hardwood industry is possible in the study area. However, the methods discussed here must be used on a site-by-site basis to assess each property.

The assessment design provided sample data from both medium (34 pct-75 pct crown cover) and high density stands. This allowed us to determine the potential for commercial management and product development.

Species composition and diameter at breast height (dbh) were found to be the best indicators for evaluating the commercial potential of a hardwood stand. The results of the study showed that the major hardwood species in the study area were black oak, blue oak, canyon live oak, interior live and madrone. All other hardwood species investigated in the study were found to be a minor component of the total population.

The study grouped specific hardwood species into associations based on common habitats, ranges, and similar grading qualities. The study identified three associations: The Blue Oak - Interior Live Oak; the Black Oak - Canyon Live Oak; and the Madrone Associations. These hardwood associations are found in larger vegetative groups such as the Valley-Foothill Hardwood, Montane Hardwood, and Montane- Hardwood-Conifer types of the Wildlife Habitat Relationship (WHR) program (Mayer and Laudenslayer 1988).

**Table 4**—A comparison of hardwood volumes with the statewide assessment.

Hardwood Association	Hardwood Volumes by Association		Statewide Data (Bolsinger 1986)		
	Mean Volume (c.f.)	Mean Volume (b.f./ac.)	Species	Mean Volume (c.f.)	Maximum Volume (c.f.)
Blue Oak/Interior Live Oak	964	2896	Blue oak	381	1767
Black Oak/Canyon Live Oak	2229	6879	Interior live	612	3779
Madrone	4330	11133	Canyon live	1503	4128
			Black oak	1213	4000
			Madrone	1705	4519

**Table 5**—Hardwood volumes by species and grade.

Species	Grade 1 (b.f./ac.)	Grade 2 (b.f./ac.)	Grade 3 (b.f./ac.)	Cull (b.f./ac.)	Submerch. (b.f./ac.)	Tot.* (b.f./ac.)
Blue oak	0	32	238	95	1104	1469
Black oak	444	1176	1054	817	910	4401
Canyon live oak	9	30	51	50	119	259
Interior live oak	0	38	18	234	955	1245
Madrone	1532	3465	3320	538	473	9328

\* The species volumes in this table are a component of the volume of their hardwood association.

The primary difference between those vegetative classifications and the system used in this study, was that in addition to considering similar habitats and ranges, comparable tree grading qualities were also used as criteria for finding hardwood associations that could be identified. This additional guideline enhances a resource manager's ability to develop specific timber management recommendations for the various hardwood woodland types found in the study area.

## Hardwood Quality

The tree grading process produced data showing that blue oak and interior live oak trees contained little merchantable timber. This is especially noteworthy because only the medium and high density stands were sampled. Canyon live oak results were highly variable, but about 35 percent of the trees were of merchantable quality. The majority of the black oak and madrone trees were classified as merchantable. It was also observed that black oak and madrone stands frequently contained trees with merchantable sized diameters. Canyon live oak was near the 12 in requirement, and blue oak - interior live oak mixtures were dominated with diameters of sub-merchantable sizes.

When considering both diameter and grading for each species, it was concluded that madrone, black oak and possibly canyon live oak trees had commercial potential for producing a variety of wood products. However, the major wood product possible for blue oak and interior live oak remains fuelwood until a more efficient technology becomes available.

If a land manager compared the medium and high density stands for each hardwood association, he will see that the Blue Oak - Interior Live Oak Association contained a majority of hardwoods with inadequate tree size or form, while the Black Oak - Canyon Live Oak and Madrone Associations have a majority of hardwoods with sufficient tree quality to be managed for commercial lumber production.

## Hardwood Volumes

Hardwood volumes per acre by association for medium and high density stands indicated the Blue Oak - Interior Live Oak Association had a low level volume, Black Oak - Canyon Live Oak had a moderate level, and the Madrone Association had

high volume of total wood available for utilization.

The volumes per acre by species and grade revealed that madrone stands produced a relatively high amount of merchantable timber, while black oak stands produced moderate levels. Merchantable sized timber was almost non-existent in blue oak - interior live oak, and pure canyon live oak stands.

## Recommendations for Management of Hardwood Associations

The Blue Oak - Interior Live Oak Association should be managed to insure adequate regeneration, particularly the erratic and highly predator-susceptible acorn production of the blue oak. Acorns must be protected from rodent, deer and livestock predation; the best protection is to insure that large numbers of acorns are produced (Oyler 1987). Managing for adequate stand basal areas will help to insure enough trees are present to produce the acorns.

The Black Oak - Canyon Live Oak Association have an extensive range within the study area. Black Oaks have very good grading qualities and their stands produce moderate levels of merchantable timber. Canyon live oaks have highly variable grading qualities.

The Madrone Association is found on some of the highest quality sites within the study area. All the species found within this Association have very good grading qualities, but their quantity is very limited. Madrones are usually found in pure stands and their stands produce high volumes of commercial timber.

Black oak, Canyon Live Oak, and Madrone have good reproduction from both seeds or sprouts (Bartolome, Muick and McClaran 1986). Seeds are usually used for genetic improvement and sprouts for vegetative reproduction.

Given these features, the Black Oak - Canyon Live Oak and Madrone Associations should be managed for the production of timber as well as aesthetics and wildlife values. Landowners are encouraged to consult a registered professional forester to conduct an on-site evaluation.

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