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LAND-USE CONFLICTS IN THE GEYSERS-CALISTOGA KGRA: A PRELIMINARY STUDY

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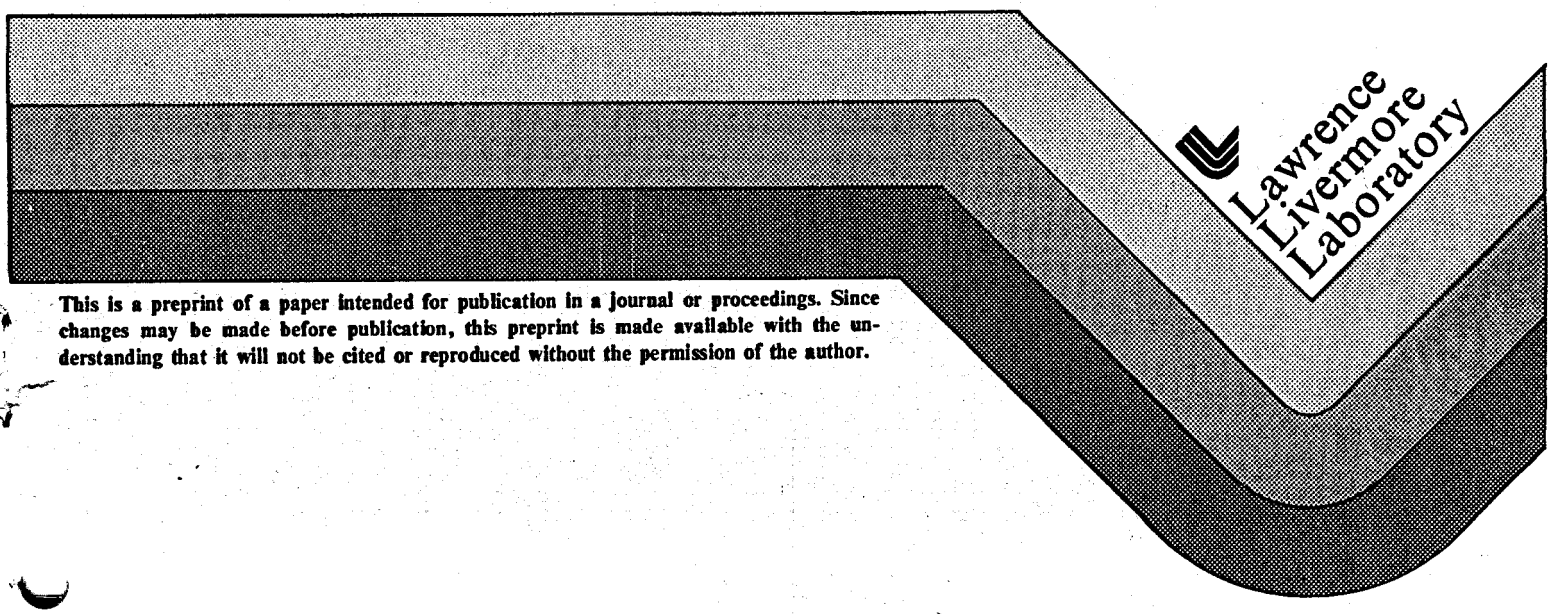

DISCLAIMER

LAND-USE CONFLICTS

IN THE GEYSERS-CALISTOGA KGRA:

A PRELIMINARY STUDY*

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ABSTRACT

This preliminary study of potential land use conflicts of geothermal development in The Geysers region, one component of the LLL/LBL socioeconomic program, focuses on Lake County because it has most of the undeveloped resource and the least regulatory capability. We first characterize the land resource in terms of its ecological, hydrological, agricultural, and recreational value; intrinsic natural hazards; and the adequacy of roads and utility systems and depict each factor on a map. We then analyze those factors for potential conflicts with both geothermal and urban development and display the conflicts on respective maps. We conclude with a brief review of laws and methods germane to geothermal land-use regulation.

The material in this study will be dovetailed with economic and demographic forecasts, now in preparation, in a combined final report in late 1980. The final report will include a more detailed analysis of potential socioeconomic impacts and land use outcomes, as well as an evaluation of policy options to mitigate adverse impacts.

INTRODUCTION

The U.S. Department of Energy (DOE) actively promotes development of geothermal energy in The Geysers-Calistoga Known Geothermal Resource Area (KGRA) through a variety of research programs and the Geothermal Loan Guarantee Program and is thus obligated by law to assess its potential environmental impacts. This particular study is one component of the Socioeconomic Research Program at Lawrence Livermore and Lawrence Berkeley Laboratories, which incorporates economic and demographic as well as land-use consequences and which, in turn, is part of a larger program at the two labs to analyze the entire range of impacts from geothermal resource development in this region.

OBJECTIVES

The objectives of this study are threefold:

- To describe, on a regional scale, the land related constraints to geothermal resource development,
- To identify policy options to minimize conflicts and adverse impacts, and
- To provide a source of data for local effects assessment and regulatory decisions.

The first and second objectives, for us, relate primarily to the design of DOE policy, but we also expect local agencies and project developers to derive some benefit from at least the first. The last objective recognizes that, particularly in rural areas with often skeletal bureaucracies, the responsibility of evaluating and granting permits for geothermal use can be a real burden. Since this regulatory load itself is, in part, an impact of DOE programs, we felt obliged to make our study as usable as possible to the counties that are involved. Thus, although we certainly do not presume to make any local decisions, we have included data that are relevant to those decisions even though they are not of direct Federal concern.

We consider this study as "preliminary" because we hope for and anticipate considerable response, both because of the importance of the issue in The Geysers region and because of the subjectivity and complexity of land-use analysis.

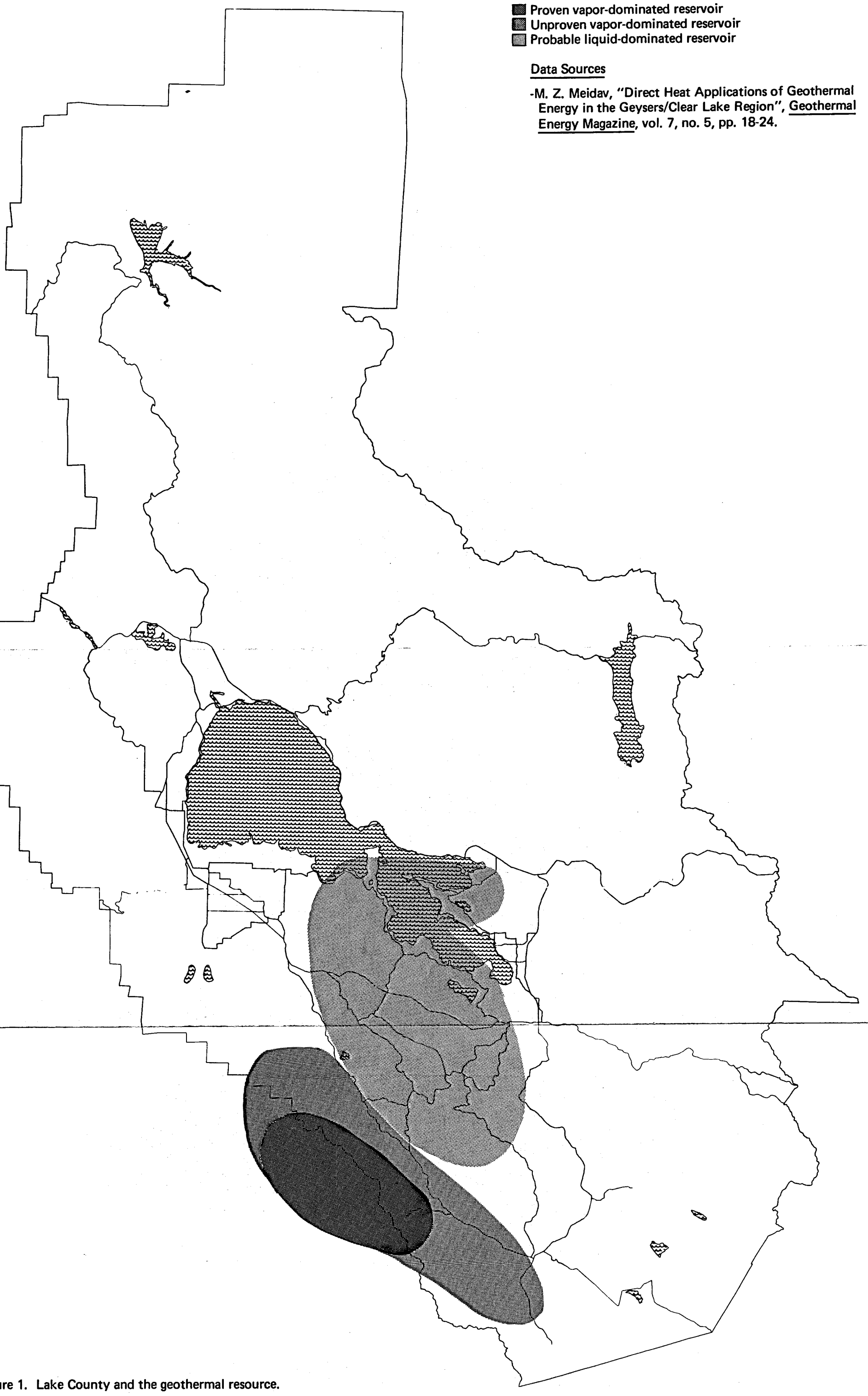
Land-use conflict, along with hydrogen sulfide control, noise control, landslides and soil erosion, and rare and endangered biota, was found to be a high priority issue in The Geysers region by the LLL Geothermal Overview Project.[1] The purpose of this project was to identify key environmental issues, to prioritize those issues, to compile inventories of available data, and to prescribe guidelines for future research. The primary mechanism to identify and prioritize issues was a series of workshops, involving Federal, State, and local agencies, developers, utilities, and private groups and individuals, as well as LLL and LBL. Certainly, since mid-1978 when the Overview Project was completed, land use has become an even more urgent concern. Geothemal resource development has extended over

the remote and sparsley populated west slope of the Mayacmas ridge, in Sonoma County, to the east slope in Lake County which forms the west side of Cobb Valley, a residential and resort area. Moreover, at a time when controls over geothermal development are more crucial than ever, the general plans of both Lake and Mendocino Counties have been declared inadequate by the state.

SCOPE

The Socioeconomic Research Program is designed to include the four counties within the KGRA: Lake, Mendocino, Napa, and Sonoma. However, because of both time and expense, we have concentrated our land use efforts first on Lake County (Fig. 1), because it has most the undeveloped resource, will experience the greatest near-term impact, and has the least regulatory capability of the four. Mendocino County may be next highest in priority for study; but unlike Lake County it is not yet subject to much commercial interest in its geothermal resources, and most of its resource is in its least populated area. Sonoma County has an extensively developed field in its easternmost portion; but although future field development may quadruple the energy produced, the relative impacts that are expected are much less than in Lake County. Napa County does not have a large, known geothermal resource, and its agriculture-oriented land-use policy will stringently constrain any development.

The need for research in Lake County is even more urgent as a result of the recent decision by the State Attorney General and Office of Planning and Research (OPR) that its general plan, adopted in 1968, is inadequate. To avoid a formal lawsuit, the County was encouraged to apply for a time extension to revise its general plan to satisfy the State's objections. This application, required to specify the interim controls to be enforced during the revision period, has been filed by the County[2] and is now under review by OPR. Before this action by the state, a committee of approximately 45 county citizens was formed in late 1978 to begin a comprehensive revision of the general plan. The first step, creation of a set of general land-use policies, has now been completed and the policies



Proven vapor-dominated reservoir
Unproven vapor-dominated reservoir
Probable liquid-dominated reservoir

Data Sources

-M. Z. Meidav, "Direct Heat Applications of Geothermal Energy in the Geysers/Clear Lake Region", Geothermal Energy Magazine, vol. 7, no. 5, pp. 18-24.

Figure 1. Lake County and the geothermal resource.

presented to the Board of Supervisors.[3] Although no formal motion of adoption was made, the Board expressed its concurrence with the policies, and we have attributed official status to them in this study.

The subject of land use can be extremely broad, since every type of environmental impact influences and/or is influenced by the use of the land resource. We have, however, limited the scope of this study to the land resource itself or, more precisely, to the physical characteristics that determine its suitability for a given use: its form, geology, hydrology, soil, natural vegetation, and existing infrastructure and use. We include aesthetic quality as a function of the above factors. We do not address issues such as traffic or water or power supply that, while certainly important to the use of a site, are largely exogenous; that is, determined by conditions outside of the site. Note, however, that we do include onsite infrastructure, because a road or a sewer or water line, once in place, becomes as much a feature of the land as the soil or vegetation. We also do not address the issue of emissions from prospective uses, i.e., noise and air and water contaminants; these are covered in detail in other LLL overview reports and a number of other documents.

PREMISES

This study is based on two premises that relate directly to the first two objectives above:

- The suitability of the land varies with each use, depending on its location and physical conditions.
- The use of land for one activity may preclude or degrade its suitability for others.

The first premise is obvious: the more we can coincide uses with the lands most suitable for them, the lower the costs we must bear to resolve structural problems, ameliorate hazards, mitigate ecological impacts, etc., and hence the more optimal our use of resources at both an individual and societal level. But land use decisions are not often simple optimization problems. Most land is suitable to some extent for more than one use, and to know only its suitability for each respective use is not enough: what, for example, are we to do when the land is equally suitable for two or more

uses or when it is moderately so for a very desirable use, but very suitable for one not so desirable? Of course, some uses can coexist quite nicely, e.g., pastureland and watershed. But far more often the second premise above holds, and a choice must be made as to the highest and best use of the land.

Highest and best use is a decision that must be made by those who must live with the consequences, and we do not presume to make decisions for the people of Lake County in our study. We do hope to provide an informational base for those decisions by

- Identifying the uses that the land must accommodate to sustain the quality of life in the county,
- Evaluating the land resource for its value for each use, and
- Identifying conflicts that may arise between development and
  - areas unsuitable for development because of inadequate roads and/or utility systems,
  - areas unsuitable for development due to intrinsic hazard, or
  - areas valuable as unimproved land, due to agricultural or hydrological capability, ecological productivity, or recreational amenity.

METHODOLOGY

Our first step was to identify and define the general functions the land resource must perform to sustain life; the second, to develop criteria to evaluate the intrinsic value of the land for each function; and the third, to compile the data on which to base those evaluations. Most of the natural and infrastructural data we used are secondary, that is, from already existing sources. References to those sources are given in the section on evaluative criteria. Data on vegetation and land use, however, were interpreted directly from aerial photoimagery. The photoimagery was also used to reconcile and update the secondary data.

We then input the data to a computer by a procedure known as digitizing, which essentially involves tracing features on maps with a device that converts points and lines into numbers (x-y coordinates). This procedure, although tedious, has real advantages. When the basic data are stored in

the computer, subroutines can be used to interpret a great deal more from them; for example, slope, aspect, and viewshed can be interpreted from topographic contours. Also, the data can be combined to rapidly and cheaply produce multifactor maps, such as the development-suitability maps included in this study. While the data are stored in the polygon form in which they were digitized, for program and display we have converted them to a grid format of 4-ha (10-acre) squares. Besides reducing computer time, this format increases the effectiveness of the maps, both because features under 4 ha are eliminated and because the uniform 200 x 200-m grid squares provide a convenient reference dimension.

Based on our evaluative criteria, we then produced a set of maps (Figs. 2 through 21) that depict the natural and infrastructural features of the county. Obviously, at a 4-ha resolution our maps are suitable only for a macroscale, general plan use. They can not, and we certainly do not intend them to, be used to assess individual projects. The detailed analysis required in an environmental impact statement (EIS) demands both finer resolution and on-site validation. On the contrary, our study is oriented not to individual projects but to the regional impacts of geothermal technology. As such, we envision it as a complement and aid to incremental, project-by-project decisionmaking by providing a context for those decisions.

We then broke the general land functions down into more specific land use types that prevail in Lake County, and in a matrix format (Table 1) identified their "potential conflicts"; that is, the potential instances of either significant natural or infrastructural constraints, or significant impact on nondevelopment functions. The potential conflicts for geothermal and habitational development are depicted in map form in Figs. 22 and 23.

Meanwhile, based on what we know so far about the steam and not water resources in Lake County, we began to develop alternative geothermal scenarios and, for each scenario, to project the demographic and economic changes to be expected, and hence the "secondary" development to be induced. The secondary and primary effects will be merged in FY 80, to enable us to estimate the timeframe and magnitude of the overall impact (see "Future Work", below).

THE LAND RESOURCE

We have characterized the Lake County land resource in terms of five general land functions:

- Development (geothermal and habitational)
- Agricultural
- Recreational
- Ecological
- Hydrological

Most of the myriad ways in which man uses, or depends on, the land resource come under these broad functional categories. We have defined the following criteria to evaluate the intrinsic value of a given unit of land for each function:

Development

The suitability of land for conventional development, i.e., for residential, sales/service, or industrial use, depends on the capability of the soil foundation, on the probability of natural hazards, and on road and utility proximity. Utility proximity, however, is not a factor for geothermal development. The criteria we selected are:

- Slope (Fig. 8)
- Soil load limitations (Fig. 9)
- Soil expansion/contraction potential (Fig. 9)
- Landslide hazard (Fig. 10)
- Earthquake hazard (Fig. 4)
- Flood hazard (Fig. 11)
- Wildfire hazard (Fig. 12)
- Road proximity (Fig. 13)
- Sewer proximity (Fig. 14)
- Water system proximity (Fig. 14)

Earthquake and landslide hazards depend on a number of conditions that vary from site to site. However, the portions of the Franciscan geologic unit composed of sheared shale and sandstone are uniformly unstable, and these we have designated as probable slide hazard areas at slopes over 15%;

two other formations, serpentinite and alluvium are designated as variable hazard areas, again at slopes greater than 15%.[4] We have not evaluated seismic hazard, except to show the known faults on our geological map; however, since any large earthquake may be expected to induce many landslides on unstable slopes, in this sense the criterion for slide hazard indicates seismic hazard as well. Soil limitations and expansion/contraction are also included for information only.

For wildfire hazard, we adopted a model developed by the California Division of Forestry. It defines hazard as a function of vegetation type, slope, and fire weather frequency, for which the entire County is rated as frequency class III, the most severe.[5] However, we augmented the model to include both forest and woodland vegetation types, that have crown densities of over 40% and 10 to 40% respectively, rather than the single woodland type in the original model. Our criterion for flood hazard is the 100-year flood plain.

We have used county policy on infrastructure, which is to "...develop land that is...served by streets, water, sewer and other public services prior to expansion into undeveloped lands."[3] We chose a distance of 1 km from highways and major roads as the land to which all but very low intensity development should be confined, but we realize that this distance is arbitrary and does not reflect that the value of road proximity is variable. For sewers and water, we simply used the existing service districts.

Agricultural

Although many forms of agriculture are adaptable to a wide range of lands, intensive crop farming is far more sensitive to climate and soil drainage, texture, slope, alkalinity, salinity, and toxicity; namely, those factors reflected in its

- Agricultural capability unit (Fig. 15)

as designated by the U.S. Soil Conservation Service (SCS).[6]

Fruit and nut production is by far the dominant agricultural sector in Lake County, with pears, walnuts, and grapes accounting for 76% of the total value of agricultural production in 1978, and is a major source of jobs and income. It is county policy to "...preserve and protect the future of

agriculture... and to enact zoning to protect agricultural lands and their water resources."[3] We have interpreted agricultural lands as those of SCS capability units I, II, and III. This is broader than the usual definition of prime land as units I and II, but not as broad as SCS's definition of "land suited for cultivation" as units I through IV, IV being "...fairly good land suited to only occasional cultivation and pasture."[6] We include unit III, "...moderately good land with major limitations in use," as agricultural land because a large amount of land now under cultivation in Lake County is unit III, interspersed with soils of units I and II. However, we show it as a distinct category on the map because land most valuable for cultivation, in Lake County as elsewhere, is also the most suitable for development; and where unit III soils exist in isolation, and not interspersed with more valuable soils, the County may be more inclined to permit nonagricultural use.

Recreational

In its most inclusive sense, recreation means an antidote to the unpleasant aspects of life, and our definition of this use category covers not only pursuits such as hiking, boating, or lounging at a hot spring, but also the everyday amenity of living in a pleasant rural environment. Unfortunately for our study, people vary so greatly in what they consider as pleasurable that no single objective scale of recreational suitability can be devised, at least none that has our confidence. For example, backpackers, hunters, and other users of the more remote, mountainous portions of Lake County would likely rate such country far more valuable than would, say, boaters and anglers who would favor the lake and its shoreline.

However, we could not ignore recreation either, given its importance to, even dominance of, the local economy. Tourism of both transients and the large number of second home owners and renters is a major source of income to the County; and inmigrant retirees constitute a disproportionately large percentage of the County populace and are evidently its main source of growth. Because both tourists and inmigrants are drawn to Lake County by its recreational amenity, and hence even minor degradation of that amenity could have major consequences for its residents, we felt obligated to

identify its most crucial and precious features, namely: Clear Lake and its shoreline, the Cobb Valley resort area, designated scenic roads, and public lands.

A real problem in evaluating the suitability of land for recreation, and its unsuitability for other uses, is identifying the boundary of the feature in question. In this study, we have taken the position that the boundary of the feature is defined by what one can see from within it, or its "viewshed", and we do so because of the visual aspect of geothermal resource development. The plumes of vapor and the cuts on the mountainsides, often visible for miles, impart an industrial mood to even otherwise pristine landscapes and would significantly degrade the recreational value of any of the features listed.

Active recreation in Lake County is predominantly water-oriented. The state has forecast that, in 1980, recreational use in the County will exceed five million activity days: 43% devoted to fishing, 17% to boating, 12% to swimming, 9% each to picnicking and camping, 3% each to hunting and group activity, and 1% each to riding and hiking.[8] Clear Lake is the largest natural lake entirely within California, and is the focus for most of this activity and, hence, the location of most recreation-related development. Although a proliferation of badly designed homes, motels, and trailer parks, particularly at its southern end, detracts from the beauty of the lake environs, viewed from a distance or from a less developed portion of its shoreline the blue-green lake ringed by low mountains remains striking. Almost as striking is Mt. Konocti, an extinct volcano rising almost 3,000 ft above the surface of the lake at its southwest edge. Cobb Valley is located along State Route 175 between Cobb Mountain, another extinct volcano, and Boggs Mountain State Forest. Although resorts established around mineral springs flourished in the valley from 1870 to 1930, most of the resorts have been abandoned or converted to other uses and replaced by motels, some trailer parks, and numerous vacation homes. The quiet forest atmosphere, a sharp contrast to the lake area, is the main attraction of the valley, although hiking and riding are popular.

In Lake County, all state highways are designated as scenic roads in the (now invalid) general plan; however, no specific regulations have so far been promulgated. The reason for our distinction between the critical viewshed of Clear Lake and the lower-order significant viewsheds of Cobb Valley and the scenic roads is based on our conviction that, as the focus of tourism in the region, Clear Lake is unique in importance, and its degradation would be catastrophic.

Although the features above are almost entirely privately owned, over half the County is owned by the Federal government: the northern third of the county is in the Mendocino National Forest, and the U.S. Bureau of Land Management (BLM) has extensive holdings along the east and west edges of the County. The Federal land is mostly remote and invariably mountainous, and it is County policy that it "...remain openspace... for camping, hiking, nature study, bird watching, and other limited outdoor activities and facilities...".[3] Although the County has no actual authority over its use, in fact the only competition for this land that we expect in the near future is from geothermal resource development. Some of the BLM acreage is already outleased to developers; the Forest Service has not yet outleased any of its land. We have presumed the entire county may at some time be subject to geothermal development interest and have included all of it in our study; however, we have excluded Federal and other public lands from consideration for nongeothermal development. Thus, our criteria for recreational value are:

- Critical viewshed: from Clear Lake shoreline (Fig. 17)
- Significant viewshed: from Cobb Valley and designated scenic roads (Fig. 17)
- Public lands (Fig. 16).

Ecological

At a global, continental, or even regional scale, we presume that the goal of habitat protection is to preserve biotic diversity. Although more tangible benefits to man, such as the derivation of medicinal products or new agricultural hybrids, can be invoked on behalf of wild plants and animals, the main reason for biotic diversity is that, as it decreases, the vulnerability of the world ecosystem increases. That is, the more species that are lost as a result of man's activity, the greater the probability some ecologic web that is critical to our survival may be broken.

It has long been recognized that, as a rule, the greater the diversity of its vegetation, the more suitable land is for a variety of wildlife. More precisely, wildlife suitability is a function of the number of vegetation types, the diversity of plants within each type, the quantity of land covered by each type, and the extent of interspersion--and, of course, the quality of food, water, and cover each type provides. The extent of interspersion is important because most wildlife utilize more than one vegetation type. Although forest species (e.g. deer, squirrels, raccoons) as a rule derive most of their sustenance from forested areas, most also make significant use of land in shrub and herbaceous cover. However, to species who feed mostly in open land (e.g., rabbits, skunks, quail, sparrow, robins), the proximity of cover is absolutely vital[9]. Our initial considerations for land habitat value, therefore, included plant diversity, relative prevalence of vegetation type, distance to other formations, proximity to water, and areas of special importance.

In Lake County, the narrow strips of riparian woodland exhibit the greatest plant diversity followed in order by mixed conifer-pine forest, chaparral, oak savannah, and pure stands of ponderosa and knobcone pine. Animal diversity within a habitat tends to correlate to plant diversity, and in a recent study of a portion of Lake and Sonoma Counties, this correlation held for the vegetation types listed[10]. By relative prevalence we simply mean the percentage of acreage in that vegetation type in the entire region. Because we want to maximize the number of types, as a rule, the less abundant a given type, the more important it is that it is preserved.

Our consideration of distance to other formations recognizes that the ecotonal or boundary areas between formations, i.e., forest, chapparal, and savannah, are far more valuable than those more isolated. We have selected 200 m as the critical distance, a very conservative figure since most open land species do not venture more than 50 to 100 m from cover; nor are less mobile forest species able to range more than 100 m or so into the forest and still utilize chaparral or savannah frequently[9]. We also recognized the importance of surface water to wildlife by designating land within 300 m of a year-round stream or other water source as more valuable. However, we realize that the influences of edges and water sources are by nature gradients more than constants.

Lastly, we augmented this general model with several areas of special biotic importance (ASBIs) designated by the California Department of Fish and Game,[11] (Fig. 18) and then defined three levels of ecological value (Fig. 19):

- Critical areas
- Significant areas
- Other lands.

In the critical category we include all the ASBIs, plus all land within 300 m of a year-round stream or spring and all riparian vegetation, that being the only vegetation type both truly scarce and diverse in composition. Although we have not found any comprehensive maps of riparian vegetation for the County, in fact we expect virtually all of it lies within the 600 m wide bands along streams; thus we show only the latter on our maps. We have placed the 400 m wide ecotonal areas in the less restrictive significant category, those being somewhat more tolerant of human use.

We have not considered aquatic biota directly in the study. At a general level, the aquatic impacts of concern in The Geysers region, mainly sedimentation due to soil erosion and releases of toxic substances, are covered by the criteria for erosion potential (see next section) and distance to surface water, respectively. In other words, a policy that excludes development from erosive soils and from areas within 300 m of water would largely obviate those impacts. Nor have we included any buffer zones for ASBIs, despite their obvious value. Conditions vary so greatly among these areas that we could not devise any universal solution, and to examine each area would be a substantial program in itself. We take some solace in the fact that any ASBI to be affected by proposed development would be analyzed in detail as part of the EIS/EIR .

Hydrological

The availability, quantity, and quality of water for both human and natural, ecological processes depends not only on the amount of rain but also on the characteristics of the land that it falls upon. Because of the steep topography and the low porosity of underlying geology in most of the County, most streams are intermittent; that is, flow results from runoff alone with no groundwater base flow. Even year-round streams have extremely

low flows by the end of the dry season.[4] In Lake County, at least, the more permeable soils are of greater hydrological importance, because most domestic and agricultural water is groundwater, drawn from alluvial basins recharged by percolation from streambeds and rain and by groundwater flow from higher areas. Such soils are also most vulnerable to surface releases of contaminants.

The value of land as undisturbed watershed also increases with soil erodibility, in the sense that erodible soils, if disturbed, tend to result in stream sedimentation and, ultimately, in altered flow and habitat characteristics. Thus, our criteria for watershed use are

- Soil erodibility (Fig. 21)
- Hydrologic capability unit (Fig. 20)

Both are ratings contained in SCS soils reports.[6] The second criterion is simply a measure of the infiltration rate of surfacial soil.

ENVIRONMENTAL ATLAS OF LAKE COUNTY

The above evaluate criteria, as well as basic environmental conditions, are displayed for Lake County in Figs. 2-21. Data sources are referenced on the individual figures.

ALTERNATIVE USES OF THE LAND

In examining the potential conflicts between prospective uses of the land and its value for the above functions, we limited ourselves to ten major land use types:

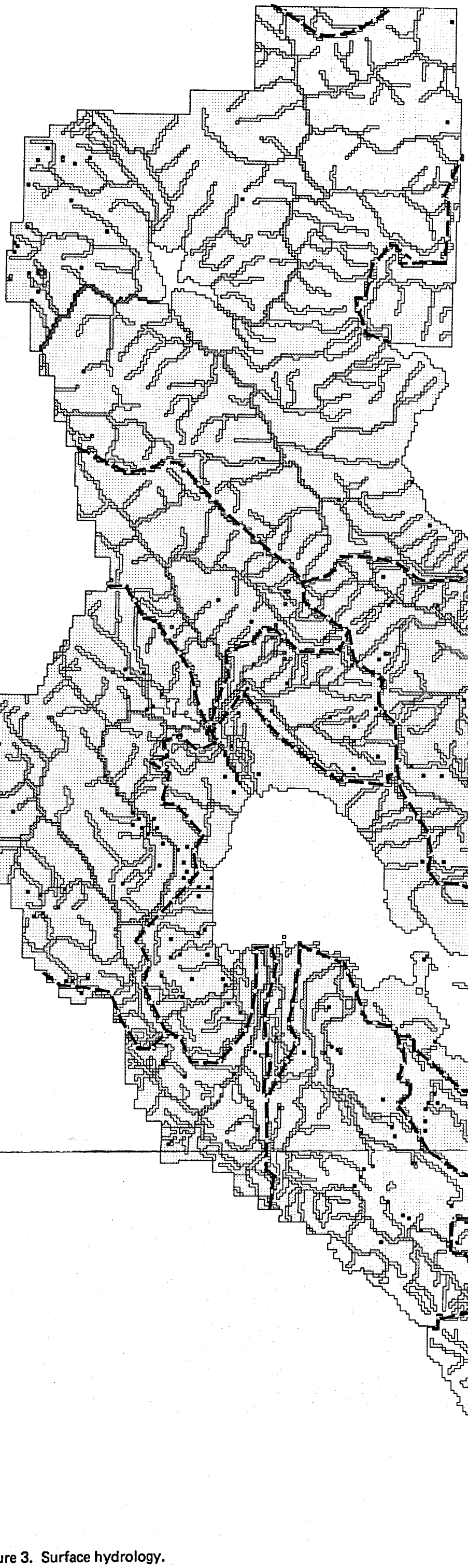
- Nature preserve
- Low-intensity recreation
- High-intensity recreation
- Extensive agriculture
- Crop agriculture
- Watershed

Symbol	Total Area (ha)	% of County
<200 m	<100	<1
200 - 400 m	27,400	8
400 - 600 m	125,400	36
600 - 800 m	81,800	24
800 - 1000 m	53,500	16
1000 - 1200 m	28,500	8
1200 - 1400 m	14,400	4
1400 - 1600 m	8,400	2
1600 - 1800 m	4,200	1
1800 - 2000 m	1,700	<1
>2000 m	300	<1

Data Sources

-USGS Base Map Topographic Quadrangles (1:62,500)

Figure 2. Elevation.



Symbol	Total Area (ha)	% of County
Study Area	257,800	74
Stream Courses		
First Order Stream	37,800	11
Second Order Stream	11,600	3
Third Order Stream	6,300	2
Fourth Order Stream	3,500	1
Fifth Order Stream	1,700	<1
Sixth Order Stream	500	<1
Spring	700	<1
Pond	700	<1
Waterbody	18,800	5
Watershed Boundary	8,400	2

Data Sources

-USGS Topographic Quadrangle Maps (1:62,500)

Figure 3. Surface hydrology.

Symbol	Total Area (ha)	% of County
Geologic Type		
Recent Alluvium	25,000	7
Recent Volcanic Rocks	2,200	<1
Quaternary-Pleistocene-Pliocene Marine and Non-Marine Deposits	18,500	5
Pleistocene-Pliocene Volcanic Rocks	27,700	8
Eocene-Paleocene and Lower Cretaceous Marine Sedimentary Rocks	24,900	7
Franciscan Formation	147,400	43
Franciscan Volcanic and Metavolcanic Rocks	14,100	4
Mesozoic Basic Intrusive Rocks	300	<1
Mesozoic Ultrabasic Instrusive Rocks	23,300	7
Knoxville Formation and Pre-Cretaceous Metasedimentary Rocks	24,800	7
Water	18,500	5
Seismic Fault*	21,000	6

*Seismic faults not displayed in waterbodies.

Data Sources

-CDMG Geologic Atlas of California, Santa Rosa and Ukiah Sheets (1:250,000)
-CDMG Fault Map of California (1:750,000)

Figure 4. Geology and seismicity.

Symbol	Total Area (ha)	% of County
Deep Well Drained Soils of Alluvial Fans and Floodplains	9,900	3
Deep Poorly Drained Soils of Alluvial Fans and Floodplains	9,500	3
Clay Soils of Basins	4,900	1
Deep Well Drained Soils of Terraces	8,000	2
Loamy Soils with Poorly Drained Subsoils and Clay Soils of Hills	4,600	1
Loamy Soils of Uplands (Sandstone)	199,400	57
Soils of Steep Uplands (Mixed Volcanic)	38,000	11
Soils of Steep Uplands (Metasedimentary)	12,500	4
Loamy Soils of Uplands Metamorphic Basic and Ultrabasic	34,200	10
Loamy Soils of Steep Uplands (Weekly Consolidated Conglomerate)	5,600	2
Soils of Miscellaneous Land Types	2,200	<1
Water	18,900	5

Data Sources

-USSCS Report and General Soil Map, Lake County, Ca.

Figure 5. Soils.

Symbol	Total Area (ha)	% of County
Needleleaf Evergreen Forest	11,600	3
Broadleaf Evergreen Forest	2,200	<1
Broadleaf Deciduous Forest	9,700	3
Needleleaf Evergreen Woodland	67,300	20
Broadleaf Evergreen Woodland	8,100	2
Broadleaf Deciduous Woodland	55,500	16
Hard Chaparral	132,600	38
Herbaceous	9,500	3
Urban/Agriculture	29,300	9
Barren	3,200	<1
Water	118,900	5

Data Sources

-USFWS Black and White Aerial Imagery (1:80,000)

-USFS Soil Vegetation Maps of California (1:31,680)

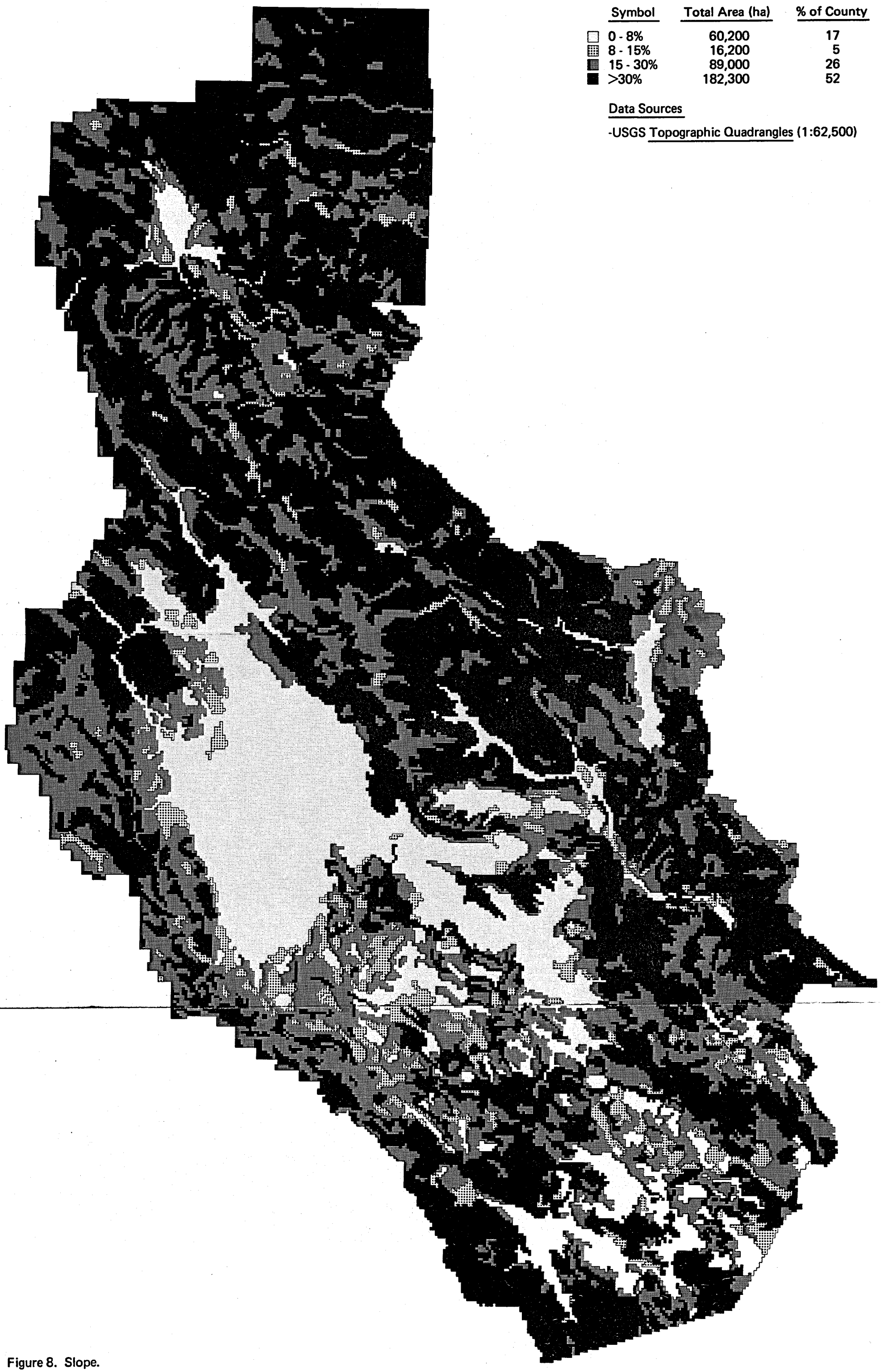
Figure 6. Vegetation Cover.

Symbol	Total Area (ha)	% of County
Settlement/Developed		
Concentrated Residential/ Commercial/Industrial/ Transportation/Other Developed	5,500	2
Dispersed Residential	600	<1
Extractive		
Surface and Subsurface Mines	300	<1
Geothermal Wells and Plants	200	<1
Agriculture		
Field, Row and Feed Crops	10,500	3
Vineyards and Orchards	7,000	2
Dry Farming/Improved Rangeland	5,400	2
Natural Land/Water	318,100	91

Data Sources

-USFWS Black and White Aerial Imagery (1:80,000)
-USFS Soil-Vegetation Maps of California (1:31,680)

Figure 7. Present land use.



Symbol	Total Area (ha)	% of County
0 - 8%	60,200	17
8 - 15%	16,200	5
15 - 30%	89,000	26
>30%	182,300	52

Data Sources

-USGS Topographic Quadrangles (1:62,500)

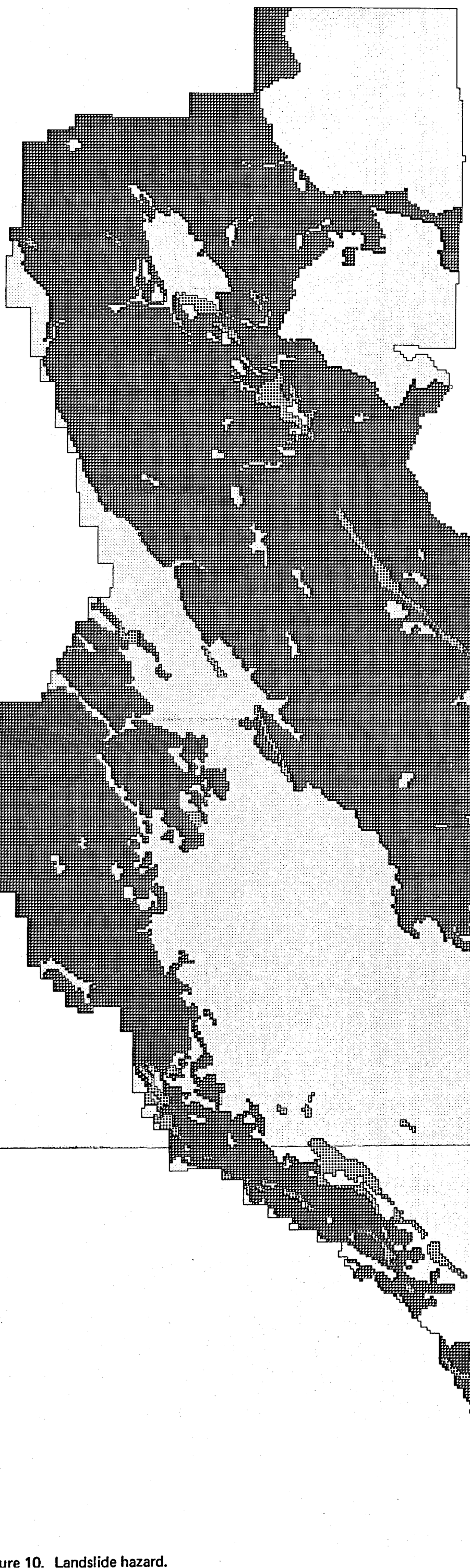
Figure 8. Slope.

Symbol	Total Area (ha)	% of County
Study Area	102,600	29
Water and Soils Not Rated	21,100	6
High Shrink Swell Potential	27,900	8
Severe Load Limitations	165,800	48
High Shrink Swell Potential and Severe Load Limitations	30,500	9

Data Sources

-USSCS Report and General Soil Map, Lake County, Ca.

Figure 9. Soil structural limitations.



Symbol	Total Area (ha)	% of County
Generally Stable	174,800	50
Variably Unstable	23,200	7
Unstable	149,800	43

Figure 10. Landslide hazard.

Symbol	Total Area (ha)	% of County
Study Area	317,700	91
100 Year Floodplain	30,100	9

Data Sources

-USHUD Flood Insurance Rate Maps (Various Scales)

Figure 11. Floodplains.

Symbol	Total Area (ha)	% of County
Low to Moderate Wildfire Hazard	60,900	17
High Wildfire Hazard	130,900	38
Extreme Wildfire Hazard	156,000	45

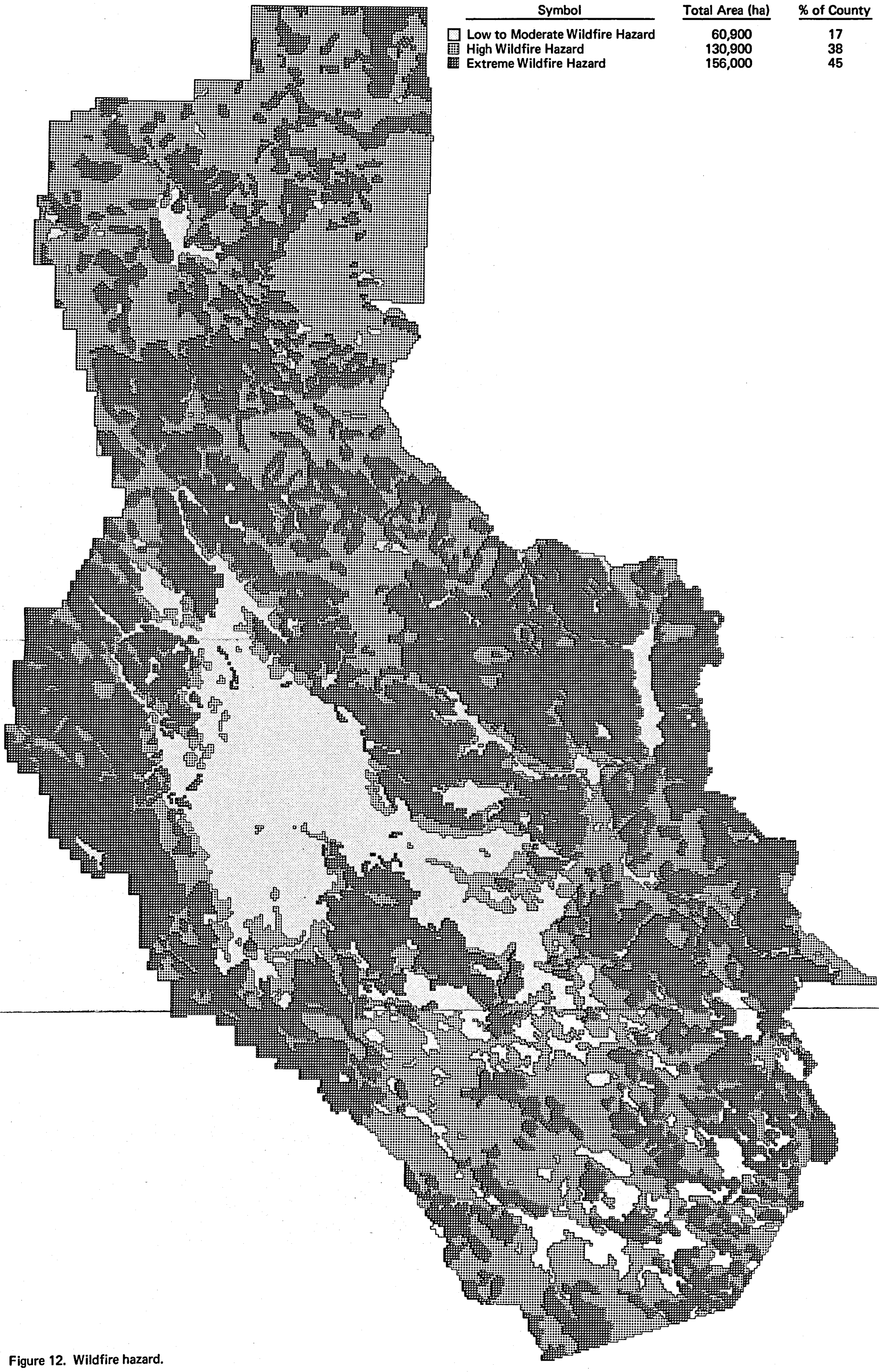


Figure 12. Wildfire hazard.

Symbol	Total Area (ha)	Proximity
Interstate, Arterial, and Major Collector Roads	8,400	2
Distance from Interstates, Arterials and Major Collecters		
<1 Kilometer	64,200	18
1 - 2 Kilometers	37,200	11
2 - 5 Kilometers	62,600	18
5 - 10 Kilometers	52,000	15
> 10 Kilometers	123,300	36

Data Sources

-USGS Topographic Quadrangle Maps (1:62,500)
-CalTrans Functional Usage and Federal Aid Road System, Lake County, Ca.

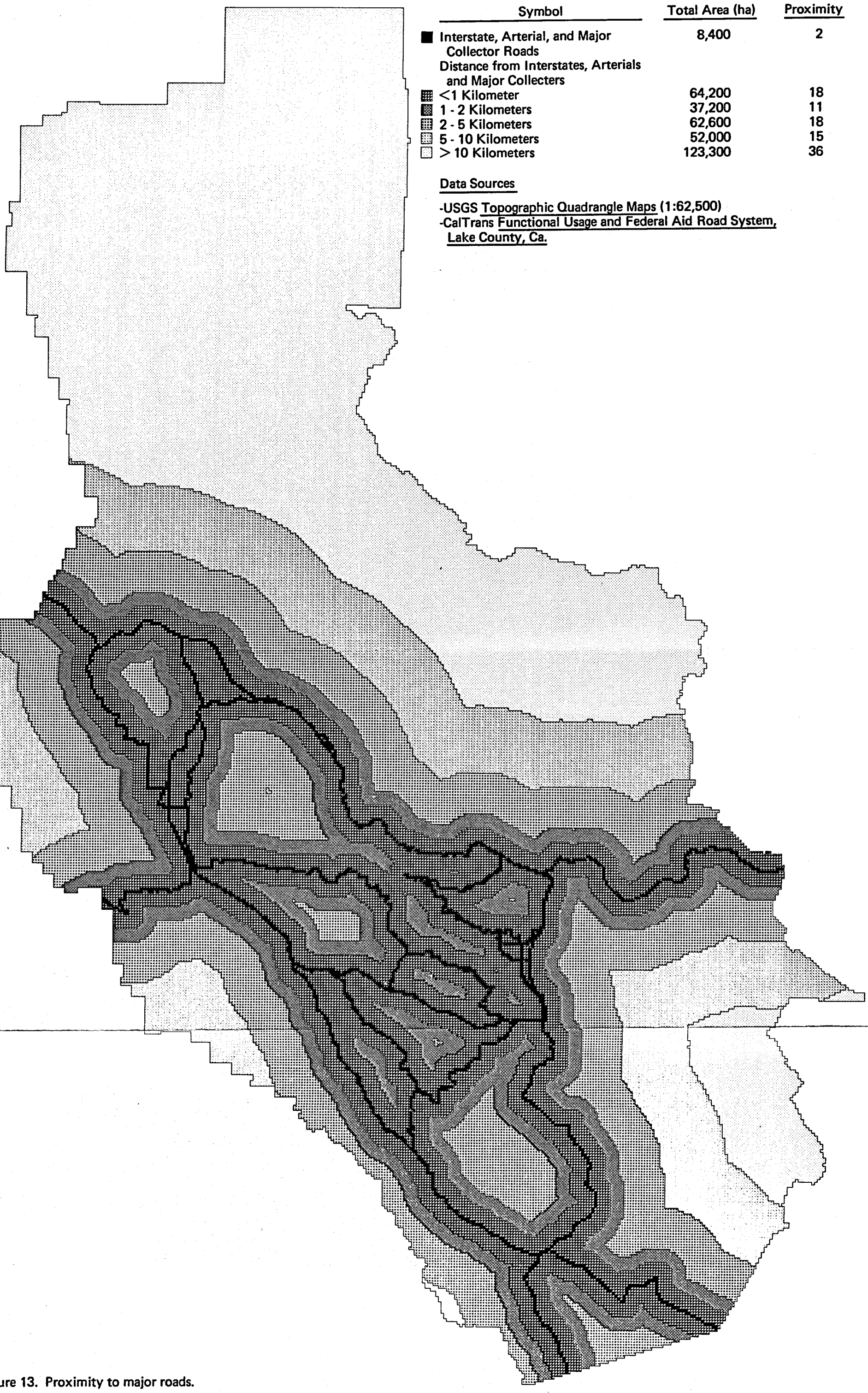


Figure 13. Proximity to major roads.

Symbol	Total Area (ha)	% of County
Study Area	334,600	96
Existing Water Service District	6,300	2
Existing Sewer Service District	2,000	<1
Existing Water and Sewer Service Districts	4,800	1

Data Sources

Lake County Clear Lake Basin Plan

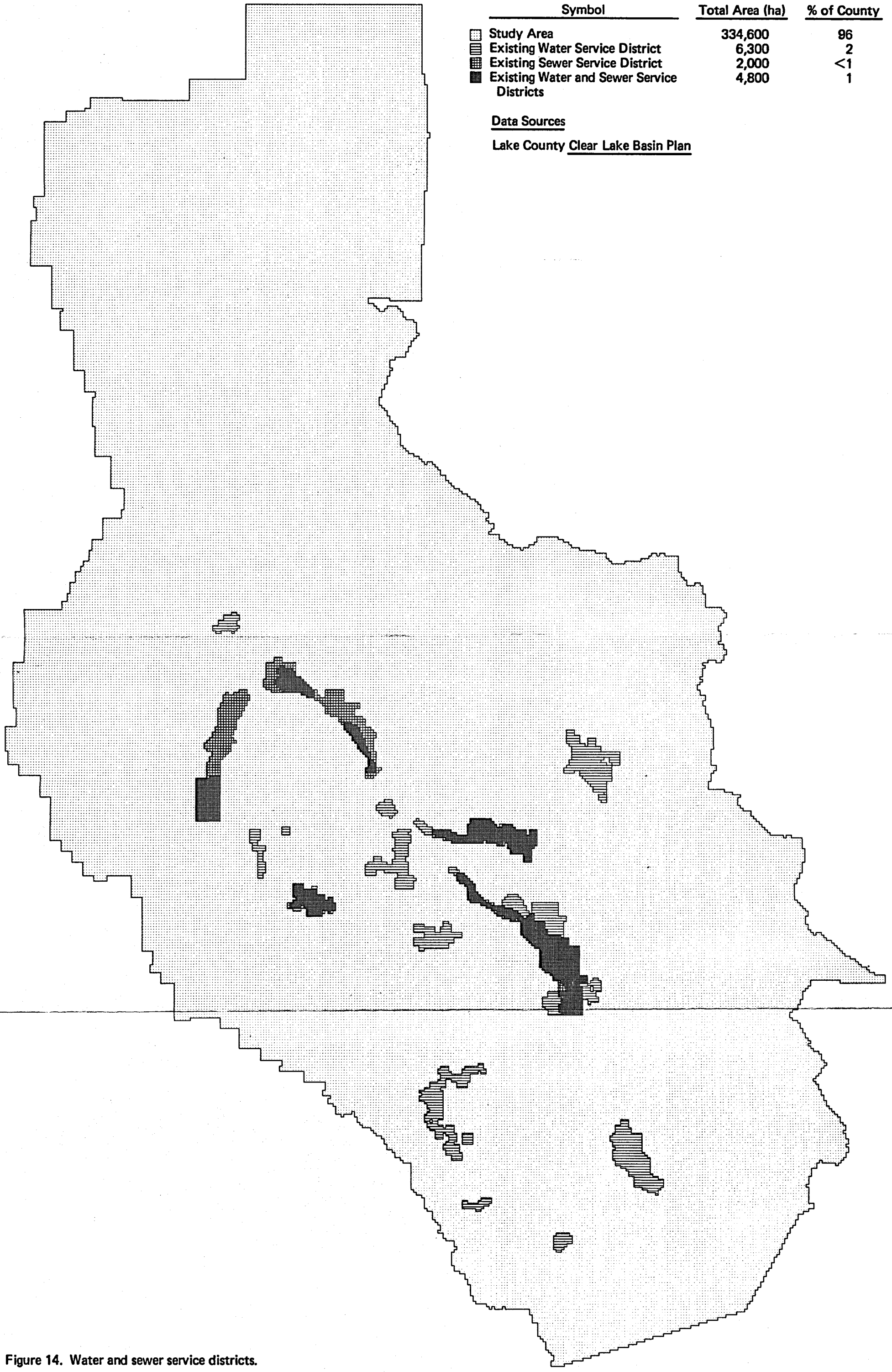


Figure 14. Water and sewer service districts.

Symbol	Total Area (ha)	% of County
Class I - II	17,000	5
Class III		
Adjacent to Class I - II	5,200	2
Not Adjacent to Class I - II	9,700	3
Classes IV - VIII	297,000	85
Water	18,900	5

Data Sources

-USSCS Report and General Soil Map, Lake County, Ca.

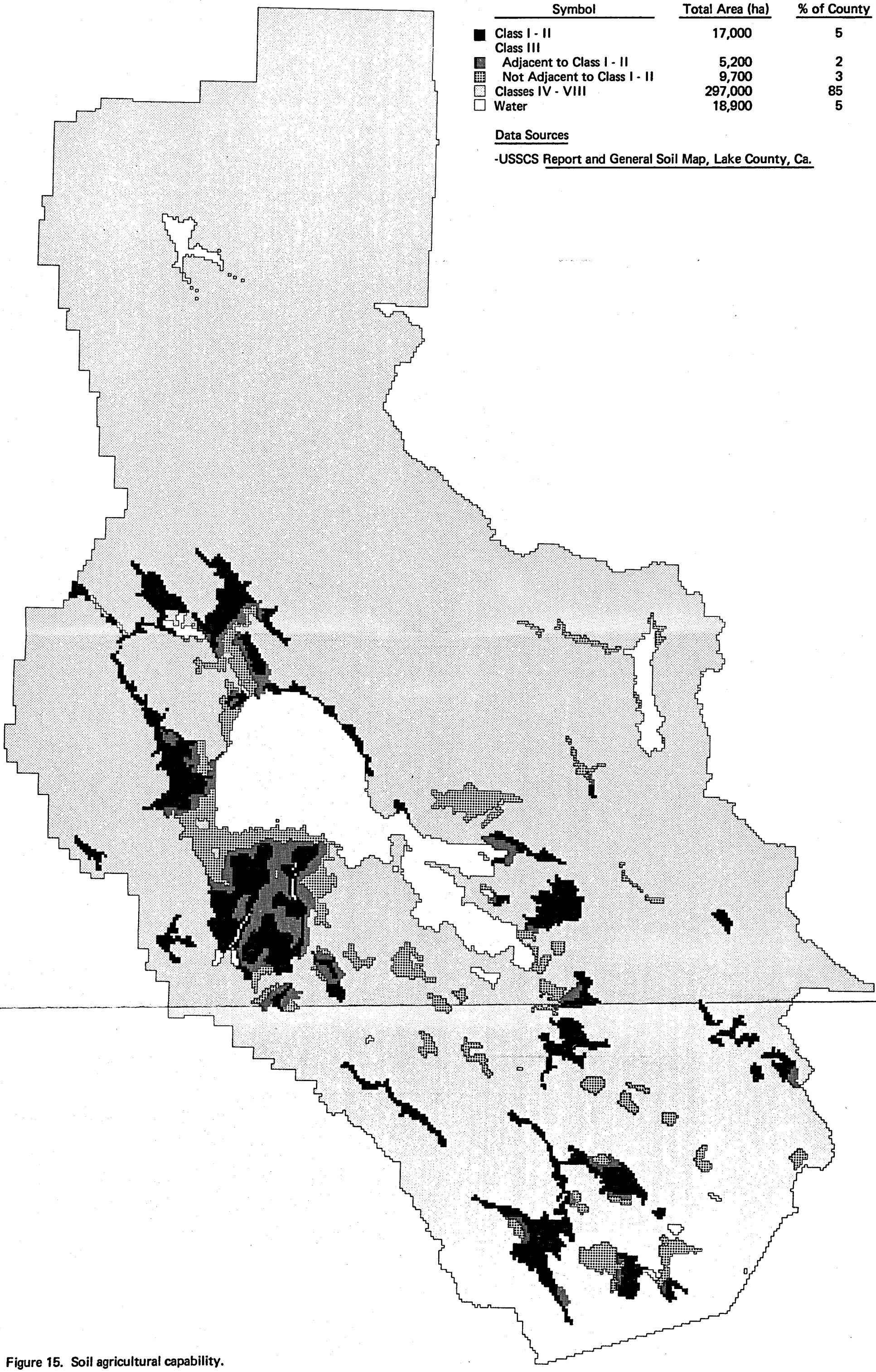


Figure 15. Soil agricultural capability.

Symbol	Total Area (ha)	% of County
Mendocino National Forest	106,900	31
Bureau of Land Management Lands	52,100	15
State Parks and Forests	3,000	<1
Other Public Lands	4,400	1
Indian Lands	400	<1
Private Lands	180,700	52

Data Sources

-USBLM, Land Status Maps, Lakeport, Willows and Healdsburg Sheets (1:100,000)
-USBLM, Land Status Map, Cow Mountain Planning Unit

Figure 16. Public Lands.

Symbol	Total Area (ha)	% of County
Study Area	213,800	61
Significant Viewshed	78,800	23
Critical Viewshed	54,800	16
Vantage Points	400	<1

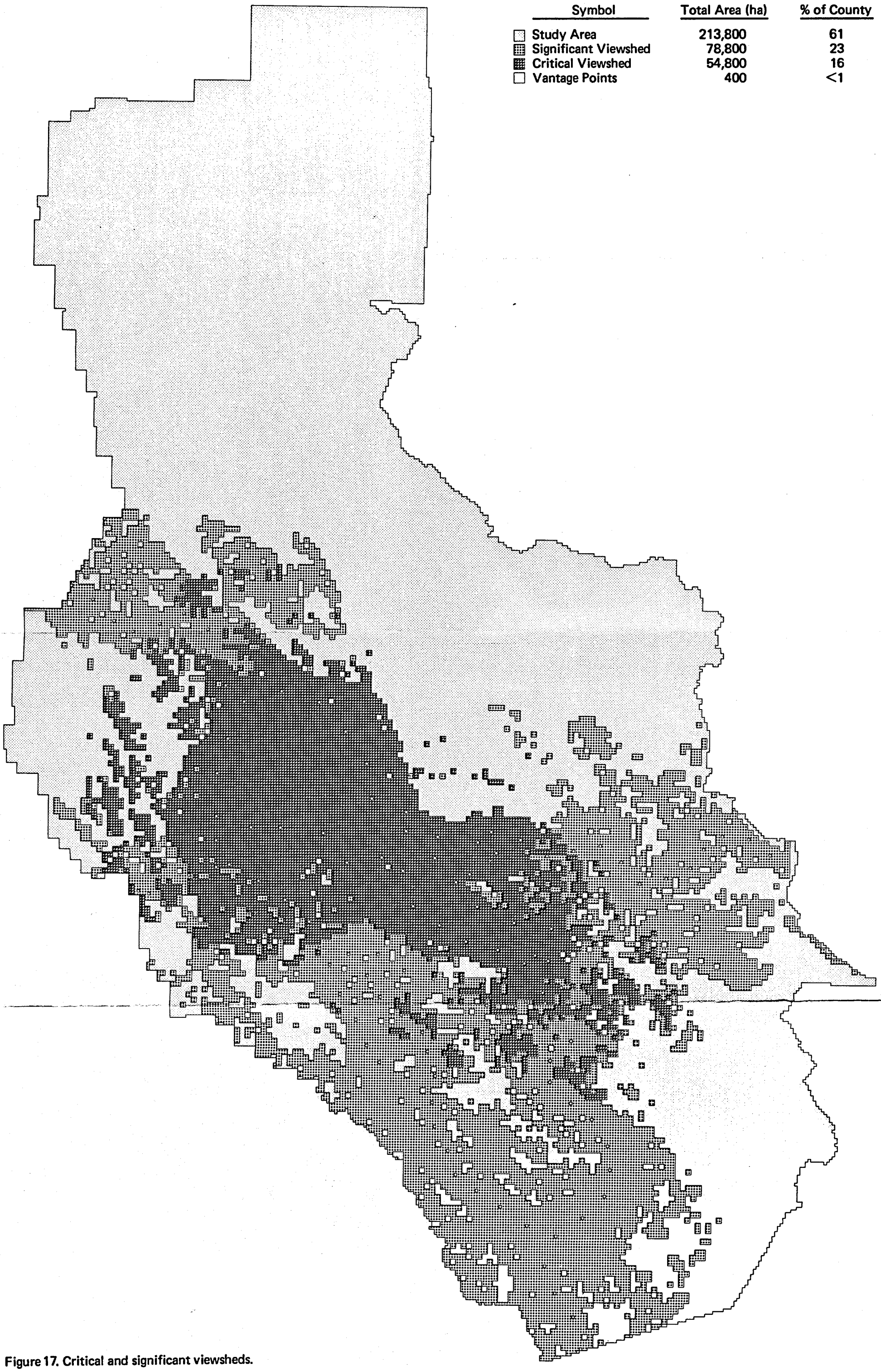


Figure 17. Critical and significant viewsheds.

Symbol	Total Area (ha)	% of County
Study Area	301,000	87
Key Wildlife Are	42,200	12
Limited Habitat	3,900	1
Rare or Endangered Species Habitat	700	<1

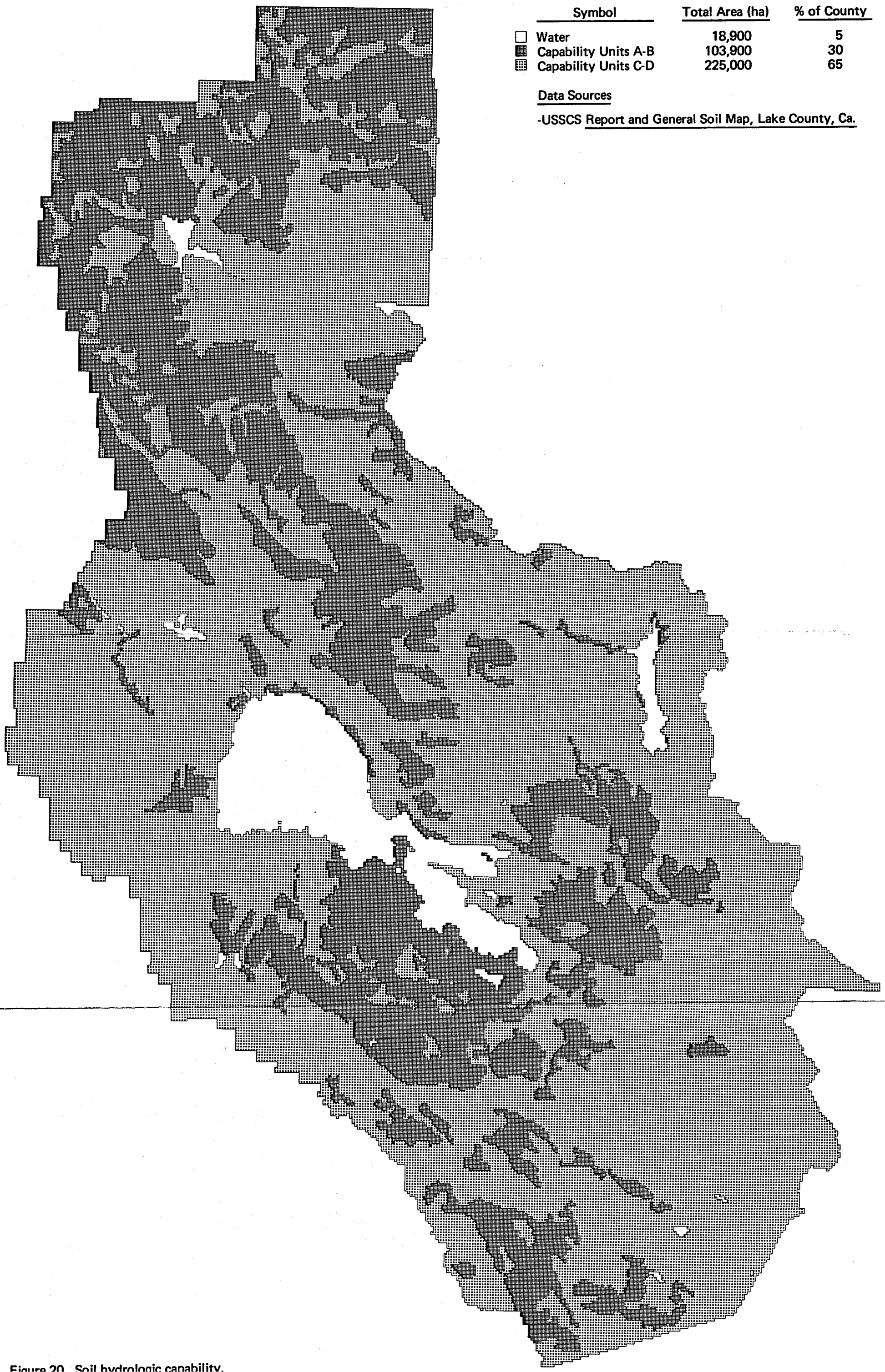
Data Sources

-CDFG Report and Maps of Areas of Special Biological Importance, Lake County, Ca.

Figure 18. Areas of special biological importance.

Symbol	Total Area (ha)	% of County
Study Area	161,400	46
Significant Ecological Area	75,100	22
Critical Ecological Area	111,300	32

Figure 19. Critical and significant ecological areas.



Symbol	Total Area (ha)	% of County
Water	18,900	5
Capability Units A-B	103,900	30
Capability Units C-D	225,000	65

Data Sources

-USSCS Report and General Soil Map, Lake County, Ca.

Figure 20. Soil hydrologic capability.

Symbol	Total Area (ha)	% of County
Water	18,900	5
Low – Moderate	164,900	48
High – Very High	164,000	47

Data Sources

–USSCS Report and General Soil Map, Lake County, Ca.

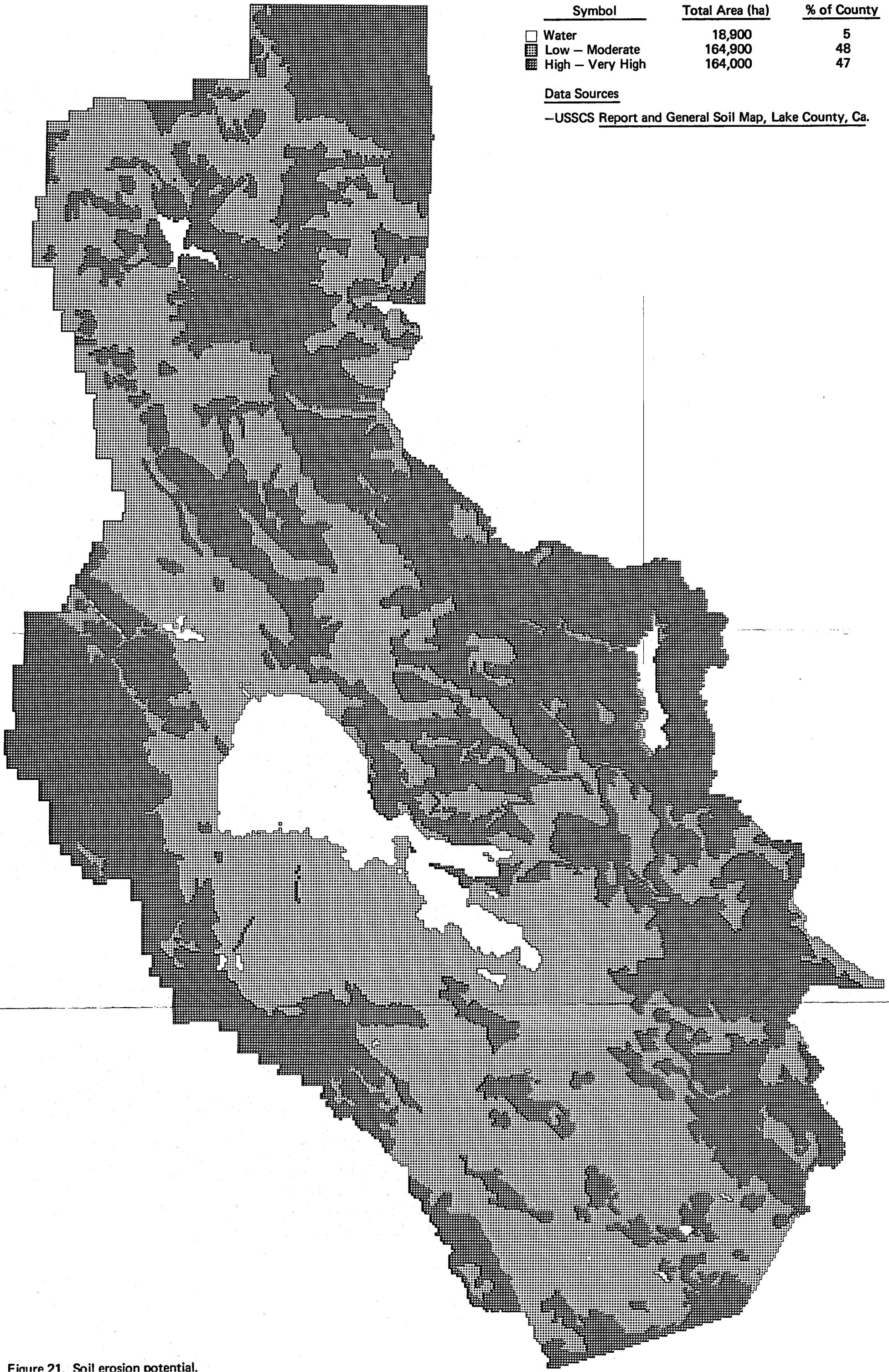


Figure 21. Soil erosion potential.

- Rural residential
- Low-density residential
- Suburban/urban
- Geothermal

Virtually all of the County is used for one or more of these purposes. We have not included the other uses that make up the miniscule balance, e.g. sand or gravel pits, mines, garbage dumps, etc. for these reasons: we saw no potential for major conflicts between those uses and geothermal development, and we felt their inclusion was not as crucial as was early completion of the study, both because geothermal interest is mounting as a result of continuing cost increases of other energy resources, and because the County has limited time to develop new land use controls.

Nature Preserve

Human activity in this category is confined to nonintrusive observation and study. The importance of such activity is secondary to the preservation of the area in its natural form.

Low-Intensity Recreation

This category includes biking, some picnicking and camping, and educational activity. Access to areas is by foot only, except equestrian use may be allowed on a day basis.

High Intensity Recreation

All the above uses are allowed, but at more intensive levels. However, the main distinctions between high- and low-intensity recreation are that (1) field and water sports and (2) access by boat or car are both limited to this recreation category.

Extensive Agriculture

Grazing on uncultivated land and timber harvesting are included in this category.

Crop Agriculture

We include all cultivated land in this category--pasture as well as orchards and vineyards.

Watershed

In this category, we include any land managed to capture rainwater. This is not an exclusive use, however, and may be combined with any other use that would not result in significant devegetation or alteration of water flow or soil permeability.

Rural Residential

Our definition of rural residential use is an average of no more than 1 dwelling unit/4 ha (∿10 acres). But ours is a functional definition and, we believe, more reasonable than more conventional ones that range up to 1 unit/ha or so. At 1 unit/4 ha, as a rule up to 5% of the land is covered by buildings, paving and landscaping. At a lower density than this the land retains at least some of its ecological and hydrological integrity; at densities not far above it, those functions are seriously disrupted. The land becomes more suburban than rural, and most of its recreational amenity is lost.

An average density of 1 unit/4 ha is low enough to permit a mixture of residential development with recreational uses or even natural areas, by varying lot sizes from 1 ha (∿2.5 acres) to 16 ha (∿40 acres) or more. Moreover, as long as lot sizes are not less than 1 ha, development need not be constrained by slope, erosive soils, or fire or landslide hazard. The policy of the County to limit development to sewer- and water-serviced areas is stated as a unilateral one; but it is not clear whether such low-intensity development as this is meant to be covered by that policy. Certainly, water and sewer systems for such areas would be quite expensive. We have presumed that, at an average density of 1 unit/4 ha or lower, the County would permit individual systems in lieu of public systems; this is far more conservative than its present regulations, which permit individual systems on lots as small as 0.4 ha.

Low-density residential

At densities greater than an average of 1 u/4 ha, the landscape acquires a more and more developed character, and the ability to integrate residential with natural or recreational areas decreases markedly until at 1 unit/ ha we reach an unmistakably suburban density, at which 15% or more of the land is covered by buildings, paving, and landscaping. We define

low-density residential areas as those having an average density between 1 unit/4 ha and 1 unit/ha.

Suburban/urban

In this category we have included industrial, sales and service, and institutional uses, as well as residential use at densities greater than 1 unit/ ha. Although we recognize that large-scale, heavy industry can pose impacts that result in greater constraints on its locational options than on other urban uses, this is not germane to Lake County. Because of its isolation, low capacity roads, and lack of rail or air service, it is unlikely any but small, low impact industries would be developed in the County, and because the characteristics of such industries would be similar to those of sales and service or institutional uses, we see no need to consider them separately.

Geothermal Resource Development

We have divided geothermal development into two components: the plant/wellfield complex and transmission lines. Because steam to be used to generate electric power cannot be transported more than about 1.6 km without a prohibitive temperature drop, power plants can neither be consolidated nor moved far from their associated fields. The areal extent of a wellfield, in turn, depends on the capacity of the plant, the density of supply wells allowed by the reservoir, and the topography of the area. The larger the power plant, of course, the more steam is required to maintain a given output, and hence the more wells must be drilled; the newer plants in The Geysers region each consist of two 55-MW units, and require 15 to 25 wells. Well spacing is governed by inherent characteristics of the reservoir; at The Geysers, the average density is 1 well/23 ha. Topography is a factor because as slope increases, so does the surface area required for development due to the extensive cut and fill involved in road and pad construction. The rugged terrain at The Geysers can require up to twice the acreage required on flat land.[12,13]

Of the gross area involved, some 350 to 600 ha/100-MW plant, only 7 to 10% is disturbed: approximately 3½% for wellpads, 1% for the power plant, 1½% for the main road, and 2% for secondary roads and steam lines. The steam lines are mounted aboveground at heights ranging from 0.15 to > 3 m;

trees and chaparral are removed along the route for about 6 m on each side of the steam line to protect it from fire. Asphalt- or gravel-surfaced roads run to each wellpad; the average width disturbed by main roads is about 15 m and by secondary roads about 9 m. Each wellpad must provide a flat, cleared, and compacted area of at least .3 ha. The plant itself requires a flat, paved area of at least 2 ha. In most parts of The Geysers region, the topography must be altered quite extensively to provide level pads of this size; in the upland areas, cuts of over 3 m are occasionally required.[12,13]

Each generation unit is connected by a transmission line to the nearest or otherwise optimal grid line or load center. All future lines in The Geysers region will be 230 kV and will have rights of way approximately 36 m wide; however, use of multiple line corridors may decrease the total acreage required, since the distance between the lines will probably be < 18 m. The rights of way are cleared of trees and chaparral, although bridges of coniferous trees across them may be provided to facilitate migration of large animals.[12,13]

ANALYSIS

This preliminary study is limited to identifying potential conflicts between the functional value of land and its prospective use. We define potential conflicts as instances when:

- The infrastructure, i.e. roads and utility systems, is inadequate,
- The site poses an instrinsic natural hazard, or
- The site is valuable as unimproved land, because of its agricultural or hydrological capability, its ecological productivity, or its recreational amenity.

Each of the above conflict types has distinct implications, and we would like to take a minute to explore them.

It is Lake County policy to confine development to areas adequately served by roads and by sewer and water systems, and our study acknowledges that policy for nongeothermal development.[3] Obviously, it makes fiscal

sense to use the existing infrastructure to its full capacity before extending it, and the nonpublic alternatives, namely, septic tanks or package plants for sewage disposal and private wells for water are regulatory burdens for the county as well as potential environmental problems.

By intrinsic hazard, we mean the propensity of a given site for landslide, earthquake, wildfire or flood damage. We have taken the position that, when other factors are equal, the greater the probability of one or more hazards on a site, the lower its suitability for development.

The issue of preserving lands that are valuable in an undeveloped state is far more complex. The first two conflict types evolve from principles, i.e., fiscal economy and public safety, that are simple to grasp and that almost everyone favors. But no such unanimity exists on the value of land in its natural form, and we would expect as much controversy over the priority of a given agricultural type or recreational feature in Lake County as we would anywhere else. Thus, in those instances for which no objective basis for land suitability existed, we were forced to use our own judgement, but we kept within what we regard as legitimate bounds.

In any land-suitability study that culminates in a general plan or a similar product, two levels of evaluation exist. At the first level, the analyst characterizes the value of the land resource for each discrete use. For example, we characterized ecological value based largely on a goal of general biotic diversity rather than protection of rare plants and animals only--a subjective decision on our part. While we are, of course, open to any substantive critique of our decisions at this level, our decisions are informed, and we are comfortable with them. The second level of evaluation, however, involves comparing the desirability of competing uses and, considering hazards and any other constraints, designating the uses to be encouraged in particular areas. As stated earlier, we do not presume to make any decisions at this level, precisely because we do not have the same equity interest in the future of the Lake County environment as do its residents.

Thus, this study does not go beyond identifying the potential conflicts that geothermal development may cause. In a year from now, we will publish a second report analyzing each conflict in detail, and relating them to alternative scenarios for development. This analysis will include other

socioeconomic impacts as well as those pertaining to land use. Beyond this, we hope to work with the County to develop and evaluate alternative policy options to mitigate those impacts, but the form and extent of this role depends on what the County desires and requires.

POTENTIAL CONFLICTS

Table 1 shows the instances in which the coincidence of a land-use type with a natural or infrastructural feature is a potential conflict. Nature preserves and watersheds are suitable uses are suitable for all lands; low intensity recreation and extensive agriculture for all except critical ecological areas. Crop agriculture and high intensity recreation, however, because of the removal of natural vegetation involved, conflict with significant as well as critical ecological areas. We also show both as unsuitable uses of steep slopes because of the land disturbance involved.

The least intensive type of nongeothermal development, rural residential, is constrained only by floodplains, prime agricultural soils, critical ecological areas, and public lands, the last only because it is County policy to preserve those lands as openspace. As the intensity of development increases, slope becomes more of a constraint; the probability of slope failure increases with percentage of land disturbance and structural load; the probability of erosion increases with land disturbance and the percentage of impervious surface; and access becomes more and more a problem. In general slide hazard is a constraint only at the suburban/urban intensity, where buildings are larger, denser, and often of concrete rather than woodframe construction. At this intensity, fire hazard also becomes a potential constraint, due to population concentration, as do erosive and permeable soils, because of the amounts of disturbance and impervious surface involved. As previously explained, only the rural residential category is not limited by infrastructural systems.

	Slope				Landslide hazard			Wildfire hazard		Flood hazard		Road proximity		Water service		Sewer service		Soil agricultural capability			Recreational value				Ecological value			Soil hydrological capability		Erosion potential	
	under 8%	8–15%	15–30%	over 30%	mostly stable	variable	unstable	moderate to high	extreme	not in floodplain	floodplain	within 1 km of major road	not within 1 km of major road	water service area	not in water service area	sewer service area	not in sewer service area	I–II	III not adjacent to I–II	IV–VIII	critical viewshed	significant viewshed	other public land	other nonpublic land	critical area	significant area	other land	A–B	C–D	low to moderate	severe
Nature preserve																															
Watershed																															
Low-intensity recreation																									●						
High-intensity recreation				●																					●	●					
Extensive agriculture																									●						
Crop agriculture				●																					●	●					
Rural residential											●							●					●		●						
Low-density residential				●							●		●		●		●	●					●		●	●					
Suburban/urban			●	●			●		●		●		●		●		●	●					●		●	●		●			●
Geothermal				○			○				●							●			●	○			●	○					○

Table 1. Matrix of potential land-use conflicts.

Geothermal Resource Development

Geothermal resource development poses a twofold dilemma for us; it is areally extensive and locationally tied to the resource. It cannot be clustered or resited to avoid environmental harm as can other, nonresource development. Unfortunately, most of the potential geothermal conflicts we have identified cover large portions of the resource area and when combined leave almost no land suitable for development. Thus, although we felt strongly that it was vital to the integrity of the study to display all potential conflicts to their full extent, we also felt that some discrimination in terms of their policy implications was in order. We therefore split the conflicts into primary and secondary and placed floodplains, prime cropland, critical viewsheds, and ecological areas in the first category and slopes that are unstable or greater than 30%, significant viewsheds and ecological areas, and very erodible soils in the second. In other words, the conflicts placed in the secondary category are those we expect to be more controversial, because they cover a larger percentage of the resource area, because no consensus on their value is evident, or both. Conversely, primary conflicts are those already recognized in county policy or at least by clear public consensus.

The area covered by floodplains and prime cropland are limited (Figs. 11 and 15) and already designated by county and other policy to be preserved for those uses. We indicate cropland as a potential conflict because, in some instances, the operational layouts of a steamfield and cropland such as orchards or vineyards would be incompatible with one another, not to mention the effects of spills or airborne pollutants. However, we are sure that in certain other instances that the two could be made compatible, given the minor amount of land surface that geothermal development disturbs.

Although the critical viewshed, i.e. Clear Lake, is large, it does not cover a large percentage of the proven or probable resource (Fig. 17); most of the resource is, on the other hand, in one or another of the significant viewsheds. Moreover, our experience is that although the importance of the lake to the local economy and quality of life is unquestionable, that of Cobb Valley and the scenic roads is quite open to question in a county- or regionwide context. The idea that Cobb Valley should be protected has been

advocated and refuted fervidly for years with no evident resolution; scenic roads, on the other hand, seem not to have emerged from the general plan as a public topic at all. Thus, although the visual damage to the landscape will be extensive in all areas, its importance in areas other than the lake basin is not resolved. We thus placed the significant viewshed in the secondary category.

Critical ecological areas, comprised mostly of the 600-m bands along streams, cover a large percentage of the resource area, and significant, i.e. ecotonal, areas much of the balance (Fig. 19). Aside from the more obvious problems of erosion/sedimentation, toxic releases, noise, etc., geothermal development may conflict with ecological areas because, even though most of the land in a field is left undisturbed, the roads and steamlines cut it into isolated parcels of land, each of which may not be large enough to be viable as habitat. Also, the construction of new roads may provide access to previously remote, undisturbed wilderness. In designating streams and other critical ecological areas as primary and ecotones as secondary conflicts, we were influenced by the fact that damage to a stream itself is not often confined to the site, but spreads downstream, expanding the zone of impact and making its remedy far more troublesome. But the main reason why we expect streams to be less controversial than ecotones is simply that a de facto exclusion of geothermal development from within 500 ft of streams (about half our criterion) now exists. That is, it is not explicit in county policy, but as a rule is incorporated as a condition of the use permit. Our draft of the revised conditions for geothermal development set by the County below, (see section on "Regulatory Instruments in Use", below) does, however, stipulate a 500-ft exclusion.

The impacts posed by geothermal development in areas of unstable or precipitous slopes or erodible soils can be, at least to some extent, mitigated by sound design. For this reason and because the percentage of the resource covered is very large (Figs. 8, 10, 21), we placed those conflicts in the secondary category. Lastly, because the percentage of a geothermal field covered by impervious surface is not significant, permeable soils are not regarded as a conflict.*

Results of the Conflict/Suitability Analysis

Figures 22 and 23 show the prevalence of potential conflicts for geothermal and nongeothermal, or habitational, development, respectively. One should note that the maps are a first iteration, intended only as a basis for further policy analysis. For example, only 3% of the county is indicated as posing no conflicts for geothermal resource development. We certainly do not intend to advocate that development be limited to that 3%. Rather, the point of Fig. 22 is that in 97% of the County, geothermal development faces one or more potential land-related conflicts and that except when its impact(s) can be mitigated or if development is prohibited some environmental harm can be expected.

In adapting this basic information to the mandates and preferences of local and other regulators, several avenues may be pursued, singly or in combination:

- Potential conflicts may be disregarded entirely; e.g., policymakers may not be ready to foreclose any development at all for the sake of scenic roads.

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* We have elected to defer the question of transmission corridors until the final report. Their most important impacts are probably visual, and a separate report on this subject, focusing on Napa County, is now being prepared as another component of the LLL/LBL Geysers Socioeconomic Program.

Symbol	Total Area (ha)	% of County
No Conflicts	8,900	3
One or More Secondary Conflicts	178,400	51
One or More Primary Conflicts	160,500	46

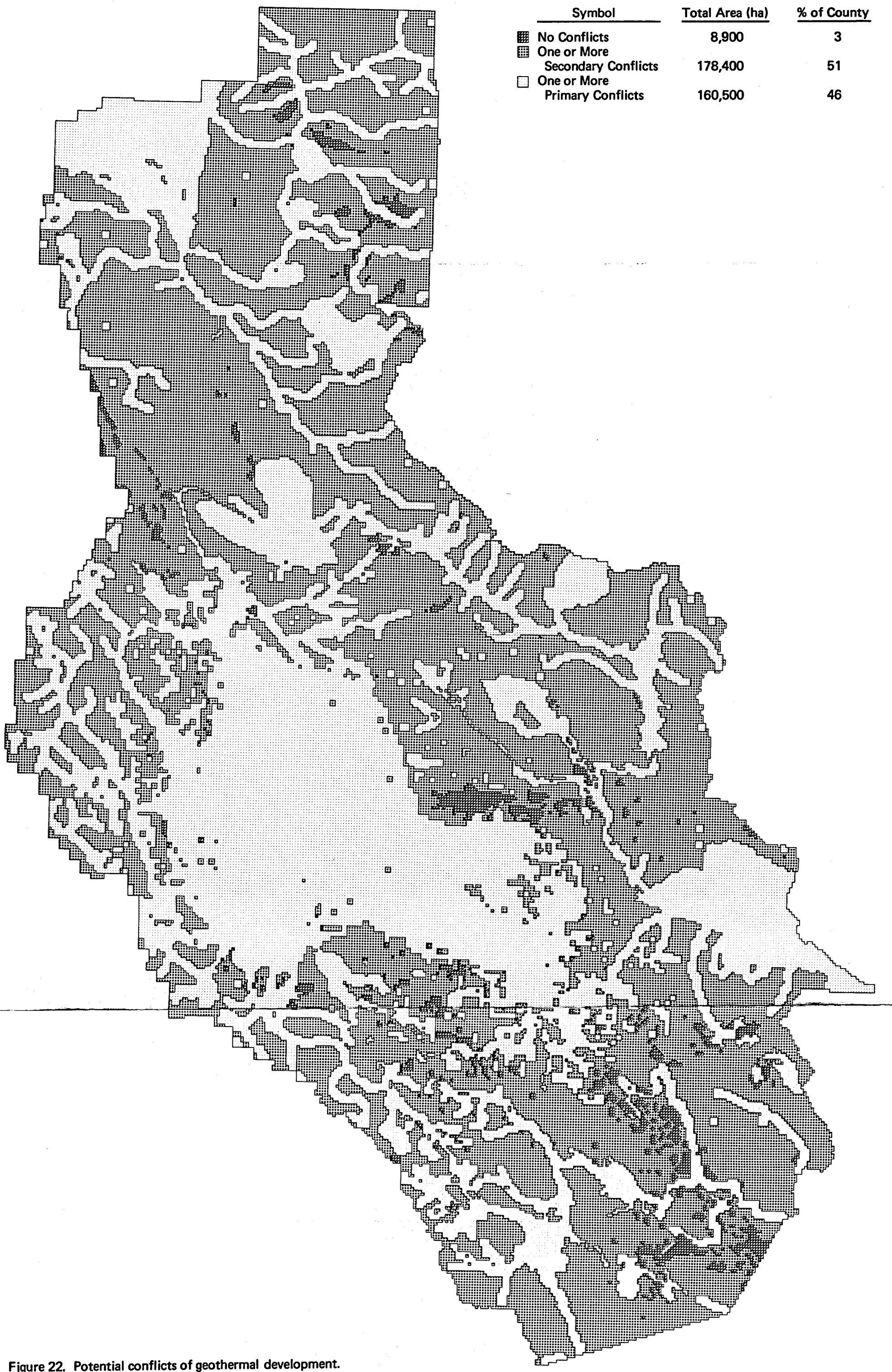

Figure 22. Potential conflicts of geothermal development.

Symbol	Total Area (ha)	% of County
No Conflicts for Urban-Suburban Development	1,100	<1
No Conflicts for Low-Density Residential Development	700	<1
No Conflicts for Rural Residential Development	102,800	30
Unsuitable for Development	243,300	70

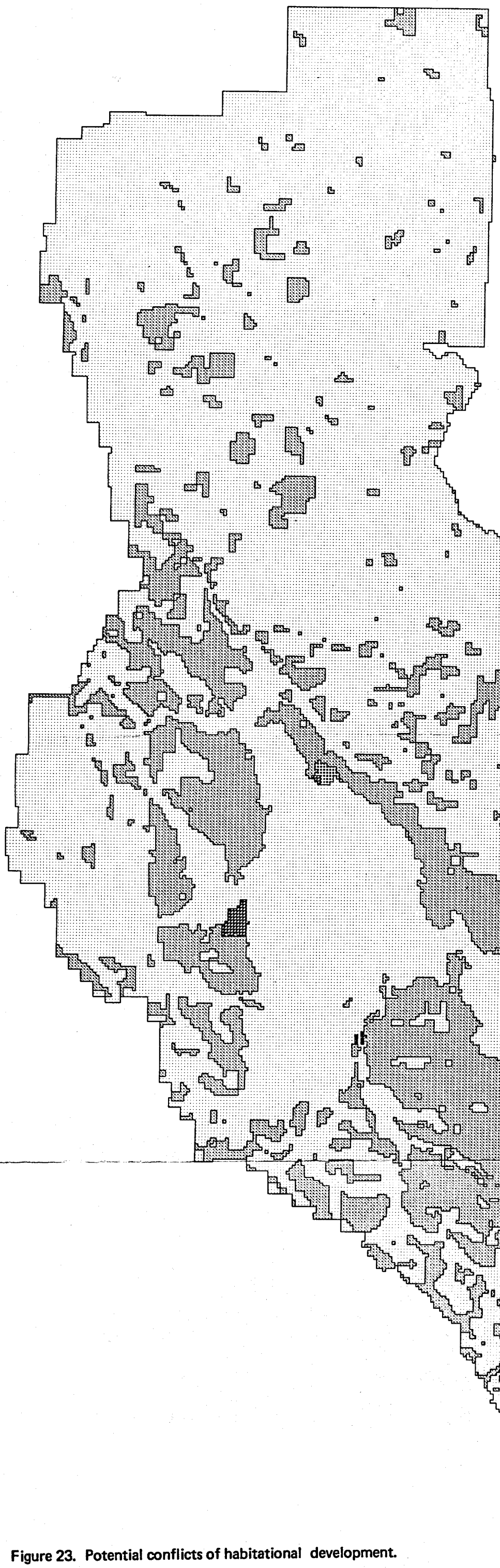

Figure 23. Potential conflicts of habitational development.

- The conflicts may be redefined; e.g., the original designation of almost every major road in the County as scenic may now be felt to be overly generous, and policymakers may want to eliminate those with less obvious value.
- The conflicts may be ameliorated only in part, not in their entirety; e.g., only a few of several road segments of equal value may be designated for protection, or, alternatively, protection may be extended only a certain distance from the roads, rather than over the entire viewsheds.
- Beyond the mere existence or absence of one or more potential conflicts, sites may be further distinguished by the number of conflicts incident at each, and further still by weighting each conflict according to its relative importance.

Because all the data in the study are stored in a computer data base, these and other options can be input and displayed iteratively. By a series of trials one can develop a best compromise between development and environmental quality, at least in terms of one's own preferences.

REGULATORY POLICY OPTIONS

We have reserved any detailed analysis of policy options for the final steps in the combined socioeconomic study to be completed next autumn. This is for two reasons: 1) given the intercausality of land use, demographic, and economic phenomena, we felt that policy could be dealt with far more effectively in an integrative context, and 2) because the premises and values we have adopted on land use are crucial to the eventual utility of our work, we wanted to provide ample reaction time before we based further work on them. However, because the range of options available to local and regional government is constrained by the statutory powers and regulatory instruments they hold, we felt a brief review of those relevant to land use was in order at this point.

We have confined the scope of this review to geothermal development itself. The means of control over the more conventional types of development that geothermal energy may induce, such as worker housing are, we felt, both familiar to most of us and relatively clear. That is, unlike geothermal development, control is vested entirely (or almost so) in local governments. Of course, much of what we say, particularly on the section to alternative instruments, is germane to all development types.

STATUTORY POWERS

The California Energy Commission (CEC) now has the "...exclusive power to certify all power-plant sites and related facilities in the state...in lieu of any permit, certificate, or similar document required by any state, local or regional agency..."[14] on non-federal lands. The California Division of Oil and Gas (CDOG) has lead agency status for exploratory wells, i.e., responsibility for the environmental impact report (EIR), but the county retains the final decision to grant a permit or to impose any conditions on a permit it deems necessary. Moreover, the county retains the same permit authority over production wells; thus, CEC could certify a power-plant site, yet the county could deny a permit to develop the associated steamfield. A county that has completed and adopted a geothermal

element to its general plan may petition CEC for plant siting authority and CDOG for lead-agency status over exploratory drilling; but Imperial County in southern California is the only county to have adopted a geothermal element to date.

On Federal lands, state and local governments have no actual statutory regulatory power. However, Federal agencies are mandated to make their programs and grants consistent with state, regional, and local plans. [15] In The Geysers region, BLM has consented that all geothermal activity on its outleased lands be governed by the same state and local procedures that prevail on non-Federal land.[16] Although it is important to note that this arrangement exists by agreement and not by law, we have assumed that it will continue and will extend to National Forest lands as well.

Well Drilling

Although The Geysers counties have no direct authority over power plant or powerline decisions, they can exercise control over those decisions indirectly through their authority over well-drilling; in effect, they have a veto power over CEC certification, the use of which is presumably to be guided by their respective general plans.

Lake County, however, distinguishes between exploratory and developmental wells in its recently adopted geothermal policy: "Exploratory projects will be considered as separate from developmental projects for the purposes of the Planning Department and the Air Pollution Control District permit procedures."[17] In other words, an exploratory project is not to be evaluated on its eventual result, i.e., a producing field and plant, but only on the impacts of the exploratory work itself, a comparatively benign activity.

As we understand it, the issue of exploratory vs developmental work arose in Lake County in an air quality rather than a land-use context. A developer seeking an exploratory permit was required by the air pollution control officer to first demonstrate that the eventual plant/field complex would not violate air quality standards; his decision was overturned by the Board and the aforementioned policy was enacted. Evidently, the rational is that 1) a developer should not be forced to bear the costs of analyzing and modeling for full development when exploration may not in fact disclose a resource to justify it, and 2) control of air contaminants is primarily a

technological problem, and exploration should not be foreclosed because of impacts that could be abated by some gadget or method yet to be developed. Whatever the merit of this rationale with respect to air quality, the policy poses a dilemma when extended to land use: how and on what grounds can a county allow exploratory work, yet not commit itself to full scale development?

Power Plants and Related Facilities

CEC has complete authority over power plant and power line siting: "...a county government would not have power to regulate or prohibit construction of thermal powerplant sites and facilities...if they should fall under jurisdiction of the state commission, but the commission must solicit extensive comments and recommendations from county government..."[18] However, the county may petition CEC for delegation of this authority if:

- The county has adopted a geothermal element to its general plan that conforms to guidelines set by the state. The element must include both a policy framework and specific criteria and regulations for development of the resource and must present the environmental impacts of development in general terms.
- The county has the capability, both technical and physical, to process applications within one year.
- The county can provide for an appropriate legal record of its actions, as well as public notification for the transcription of all hearings.[19]

However, given that an applicant or any other interested party would have the right to appeal county decisions to CEC and because the county can exert a large measure of control through its permit authority in any case, we are inclined to concur with the CEC Geothermal Advisory Committee that most counties do not intend to pursue such delegation.[19]

The Taking Question

Where land has special value for resource extraction, regulations that preclude it can reduce the value of the land significantly, particularly where alternative uses are few and marginal. In those instances, land- or mineral-owners frequently contest such regulations on the grounds that they constitute a taking, i.e., a governmental action whereby the owner of property is deprived of all or most of its beneficial use. To be sure, the

U.S. Constitution states "...nor shall private property be taken for public use without just compensation."[20] However, until the late 19th century the idea of taking was limited by court decisions to actual physical seizure; in general, no indirect or consequential damage, including loss of value resulting from regulation, was held to require compensation. However, the direction of the courts was to be changed by Justice Holmes who, in a series of decisions in the period 1890-1920, developed the notion that governmental powers to acquire and to regulate land differed only in degree. This series culminated in 1922 with his now-famous decision in Pennsylvania Coal Company vs. Mahon: "The general rule at least is, that while property may be regulated to a certain extent, if regulation goes too far it is recognized as a taking."[21] Based on this general rule, the courts have in subsequent cases adopted a sort of balancing test, weighing the public benefits of regulation against the landowners' loss. As may be imagined, in the absence of any more definitive doctrine than Holmes' rule, interpretations of just what is fair or balanced vary widely from court to court. However, at least two trends of note have emerged.

One is the tendency of the courts to favor regulations that control those uses of land regarded as nuisances; i.e., activities or facilities that impair the health, safety, comfort, or morals of the citizenry. The other, particularly evident in the last, post-NEPA decade, is a strong tendency to favor regulations that are state-wide or regional in nature; although the courts are also upholding local regulations fairly consistently, they show an obvious bias toward those having broad multipurpose goals.[22] One reason may be that the integrity or at least objectivity of a state or regional body is considered much greater than that of the local entity. The latter may be perceived as more prone to legislation for quasiprivate ends--a hometown developer, for example.

Most land-use regulation contests arise in the state courts, and no state court sees itself as particularly bound by decisions in other states. The Supreme Court of California, however, seems unlikely to hold any regulation invalid under the taking clause and apparently considers the idea of regulatory taking more as a hypothetical than a real possibility. But perhaps more important than actual legal precedent is the myth of the taking clause: a powerful image of the clause as the embodiment of every man's

right to buy and use land for a profit. This myth fosters the idea that far less can be done to regulate land use than court decisions in fact permit. The danger, in our minds realized more often than not, is that local governments may fail to exercise the powers they have or back down quickly when contested.[22] In the case of resource extraction, particularly of geothermal resources, the position of local government is doubly vulnerable, because any regulation that prohibits that use not only devalues the land, but also constrains the resource developer to a far greater extent than is so in development of other types: the developer has almost no recourse to alternative, more suitable plots of land.

As geothermal development extends over the Mayacmas ridge from the almost uninhabited mountains of Sonoma County down into more populated and more sensitive areas of Lake County, we expect the taking argument to be heard more and more from developers as a counter to prospective regulatory decisions and plans. The spectre of eternal litigation may be raised, and a small, poor county like Lake County must take this seriously. Nevertheless, it is clear that as long as a regulation or decision does not entirely deprive the landowner of its use and is demonstrably based on the general public well, it is reasonably certain to be upheld even when land use is severely curtailed, e.g., when geothermal development is prohibited.

REGULATORY INSTRUMENTS IN USE

Zoning

Zoning is an exercise of the police power that resides in the state, although in California, as in most states, this exercise is delegated to city and county governments. The state requires that zoning conform with a city or county general plan and prescribes the content of the plan in some detail. As well as a general development policy, the plan must include a set of elements focusing in detail on land use, circulation, housing, resource conservation, open space, noise, safety, seismic safety, and scenic roads.[23] Other elements may be included at local option. However, the control that the state has over a local general plan is only procedural in nature; that is, it is confined to format, subjects covered, consistency of

its parts, and so on. In the case of Lake County, its general plan was held to be invalid, both because it lacked a safety element and because it contained, in the County's words, "...certain other ambiguities and inconsistencies..."[3]

The power to zone is the power to exclude certain uses of land from prescribed areas and, conversely, confine them to others. In its most basic form, a zoning ordinance consists of a map of the city or county laid out in districts and a list of uses permitted in each, described both by activity type (e.g., residential, industrial) and by quantitative criteria (e.g., density, bulk, floor/area ratio). As well as those uses that are unilaterally permitted or not permitted in a given zone, the ordinance may designate certain other uses as conditionally permitted, that is, subject to additional provisions specific to the site and use in question. The idea is, whereas some activity or facility types can be defined as incompatible per se, e.g., a smelting plant in a residential area, others may or may not be depending on their design, environs, or mode of operation, e.g., a nursery in the same area. In Lake County, geothermal drilling is now a conditionally permitted use in all zones, although the county geothermal regulations do specify minimum distances from hospitals (1 mi); subdivisions, populated areas, and schools (1/2 mi); residences (500 ft); and public roads and the parcel boundary (100 ft).[24] Thus, beyond these exclusions, permit conditions are presently the only control device over geothermal resource development that the county has, although conceivably very sensitive areas might require such extensive conditions to avoid environmental harm that development would be precluded because of cost.

Permit Conditions

Conditions on geothermal permits in Lake County are presently based on (1) the draft EIR for the project and (2) the county Conditions, Procedures, and Performance Standards for Geothermal Regulation.[24] The Conditions document, adopted in 1972, is presently being revised; the new version is to be comprised of general development policy, generic conditions for all aspects of development, and performance standards, both general and for sensitive areas.[25] Preparation of EIRs for well drilling, as we mentioned above, is now administered by CDOG. However, in contrast to the case of plant and powerline siting, we think counties having geothermal resources

are far more likely to pursue delegation of this authority, once their geothermal elements are completed. Although no real increase in regulatory power is involved, the counties would gain more control over the quality and veracity of their primary (and frequently only) data source for site-related impacts, the project EIR.

REGULATORY ALTERNATIVES

Exclusion

With the few exceptions contained in the geothermal Conditions, exclusion is not presently used in Lake County to control geothermal development: it is conditionally permitted on all lands. Under this arrangement, the county has the advantage of maximum discretion. No site is precluded absolutely, yet every one is subject to individual review and, subsequently, a set of permit conditions tailored to fit its characteristics. The conditions, of course, must be based on policy and criteria determined in advance to ensure equal protection under the law--in the case of Lake County, the aforementioned Conditions. The problem, however, is that for some sites or impact types, state-of-the-art mitigation is not adequate to prevent significant environmental harm. Consider the visual impact of a plant/field complex on the Clear Lake viewshed, for example. The 1972 Conditions require only that such a development be

> ...harmonious in appearance with the area and not of obnoxious, undesirable, or unsightly appearance. A landscaping screen shall be installed to the approval of the County Planning Commission...All roads shall be constructed in such a manner as not to upset the natural aesthetics of the landscape[24]

In the most recent (May 1979) draft that we have of the revised geothermal conditions, the language is hardly more precise:

> ...the operator shall reduce visual impact where feasible, by careful selection of sites...The design and construction of facilities shall be conducted such that the facilities will blend into the natural environmental setting of the area by appropriate use of landscaping, vegetation, compatible colors, and minimum profiles[25]

The ambiguity of such policy is not due to a lack of either eloquence or resolve on the county's part; it simply reflects the fact that, presently at least, not a lot can be done to make a geothermal plant unobtrusive, particularly on a grass- or chapparal-covered slope that faces a large body of water. In such situations where a precious resource is involved, the county may want to prohibit geothermal development as the only way to avoid significant damage.

Exclusion of a given use can be promulgated in two ways: by area or by criteria. Exclusion by area simply entails identifying the spatial boundary of a given feature and designating that area in the zoning ordinance to preclude the use in question. Exclusion by criteria, on the other hand, requires only that the feature to be protected be defined in the ordinance text, and compliance with the ordinance must be ascertained on a case-by-case basis. The exclusions prescribed in the Conditions that forbid geothermal development within certain distances of other types of development are examples of this method.

Both have advantages and disadvantages. Exclusion by area is unquestionably easier for both the county and the developer: one only has to glance at a map to know if a given use is or is not prohibited. However, this method can only be as effective as the map is accurate, and it is almost inevitable that the map will omit some features because they are too small to show up, came into existence after the map was created, or simply had not been discovered, as is often the case in remote areas. Such features would be disclosed if an EIR or EIS is prepared, but, as a rule, unless they are covered by some other statute the developer is under no legal obligation to preserve them.

Moratoria, Interim Controls, Time Phasing

Implicit in any delay strategy is that some condition relevant to new development is expected to change in the future and that to permit development to continue under existent regulations may in some way be adverse to public welfare. One example is the interim controls Lake County has proposed to be enforced while it prepares its new general plan. The quite reasonable fear is that, because the new plan is anticipated to be more restrictive than the old one, landowners and developers will rush to obtain construction permits while the more lenient old controls

prevail--controls now recognized as inadequate and defective on many counts. Mendocino County is under a moratorium for the same reasons, having declined so far to formulate interim controls.

Another widespread example of delay strategy is moratoria or time phasing based on adequacy of public facilities, sewer systems, for instance. In the typical case, the rate and location of development is tied to a plan for public capital investment in a circular sequence: development is confined to areas where adequate services exist, and services are provided to areas that are timely for development. In other cases, local governments favoring slow or no growth have implemented only the former step. However, to ensure against undue or arbitrary restraint, the developer is often allowed to provide the required services or substitute a cash payment.[26]

A strategy of delay is obviously relevant to geothermal development in regard not only to the general plan but also to a county geothermal element, should one be undertaken. But we do not see any other impending changes to justify such measures, at least that can be anticipated today. The characteristics that result in land-use conflicts, namely, areal coverage, surfacial disturbance, and visual impact, are intrinsic under present technologic and economic conditions. Except for an occasional access road, geothermal development itself is largely independent of public services. However, the binary-cycle technology for liquid-dominated reservoirs would require an external water source that may have to be obtained from a public system. Of course, adequacy of public facilities is directly relevant to any residential or other development that geothermal development may induce. Lastly, a seriously underbudgeted government could conceivably make a case for delay on the grounds of regulatory incapacity; however, because permit fees can be adjusted to compensate for regulatory costs, we doubt such a rationale would hold up if contested.

MARKET ALTERNATIVES

All the above control methods are nonmarket in nature,that is, they involve government adopting regulations and enforcing them directly. To date, government action on behalf of the environment in the U.S. has been almost entirely nonmarket. Although such methods have a number of problems in general,[27] two are particularly key to environmental policy:

- The creation of regulations, whether by elected body or a delegated agency, is heavily influenced by personal subjectivity. Motives and incentives are not explicit, and hence decisions are far more prone to manipulation by interest groups at the expense of the general public.
- On the other hand, beyond the cost of adopting and enforcing them, as a rule government is not liable for the economic impacts of its regulations (see above, "The Taking Question") and can thus act with impunity in decisions that can involve substantial private resources.

Central to both problems is that regulation can be manipulated to confer benefits without cost. In the first case, a company or industry may avoid large expenditures on impact mitigation by comparatively minor outlays on individual persuasion and public relations campaigns. In the second case, even when government acts in honest behalf of its citizens, it may impose regulations favored by those citizens only because they do not have to bear its costs, at the expense of the landowners and developers who do. (We must point out that this is an economic and not a legal argument, and not one we necessarily endorse.)

Economists, in general biased in favor of market solutions, have devised a number of alternatives to environmental regulation. However, most require that standards be set in advance and are thus as subject to the above problems as is regulation itself. We will examine one type that is not, the auction of rights to lower environmental quality.

Imagine that ownership of a resource is vested in a public corporation distinct from the local or regional governmental unit, which has the power to auction off all rights to use the resource. The rights to reduce its environmental quality are put up for auction, with industry and, say, the county vying with one another. When the first unit is put up for bid,

industry may outbid the county because the cost of the last unit of mitigation will be high for industry, but a small initial reduction in quality will not be of great importance to the people of the county. The second and some subsequent rights may also be won by industry, but ultimately, as the value of successive rights decreases for industry and increases for the county, industry will be outbid. At this point the auction ceases, because industry cannot skip a level of mitigation. Industry would be required to pay the public corporation for all units it purchased, the revenues being used to mitigate or otherwise compensate for the impacts to which it has acquired rights. The county would be required only to pay for the last, and as a rule cheapest, unit.[27]

The above system, as may be obvious, was designed with air and water emissions in mind, impacts that can be easily measured and mitigated to any of several levels. In the case of geothermal land use, however, the features of a project that influence the magnitude of its impacts are largely fixed by technology and resource quality. Even so, in most instances the system could be adapted to some extent. For example, the disruption of faunal ecology by geothermal activity could largely be avoided by burying the steam lines which, although three to five times as expensive, is feasible.[28] Its adverse visual and recreational impacts could be mitigated in part by more careful and generous revegetation of cleared land etc.

A more troublesome aspect of such a market-type device to us is the doubtful fiscal ability of a poor, sparsely populated county to compete with an industrial giant determined to develop a large energy resource. Aside from the moral question of whether power to regulate land use should depend entirely on ability to pay, the practical result of such a device in such a county would be minimal control at best, given the limited funds it could draw upon. On the other hand, <u>partial</u> reliance on a market-type device has more promise. If the <u>most</u> precious aspects of the county or regional environment are protected by regulation, a device such as described above may be used to control the balance of development, where the impacts posed are undesirable but not catastrophic. One conceivable advantage of such a

procedure is that the other actors, namely regional, state, and federal government, and even private advocate groups could participate in the auction to reflect the fact that land resources within the county may have value to groups other than developers and county residents.

FUTURE WORK

This study is one component of the LLL/LBL Social and Economic Research Program for the Geysers-Calistoga KGRA, described in the LLL report of the same name.[29] The whole program is summarized in Fig. 24 and Table 2 taken from that report; this study comprises Work Products 1 and 4.

Work under the program in Fiscal Year 1979, that is, through September 30, proceeded along two parallel tracks (Fig. 24) through Products 3 and 4, respectively; the tracks converge in Fiscal Year 1980. For each projection of geothermal development chosen to be analyzed, we will use the economic and demographic forecasts to estimate quantitative land and infrastructure demand. These will be integrated with data on land-use conflicts to develop potential land-use configurations for each projection, i.e., the consequences of alternative levels of development for the land resource. We will then analyze those potential configurations for their land use and demographic, economic, and fiscal/infrastructural impacts.

Once we identify significant impacts and alternative mitigation policy options, local representatives will evaluate those options for their efficacy and their effect on geothermal and other development. The final outcome of this process, we hope, will be some optimal combination of development and environmental conservation that can be used as a basis for local, state, and Federal regulation.

Any study can only be as useful as its premises and interpretations are valid, of course, and before we continue we need feedback from those of you who, we admit, are closer to the problems herein than we are. The past year in Lake County was an extraordinary one: an almost complete turnover of the Board of Supervisors, evidently representing a marked change in orientation as well as composition; the dismissal of the planning director and the loss of almost the entire staff, a condition that prevailed for months and has only now begun to be resolved; the invalidation of the County general plan;

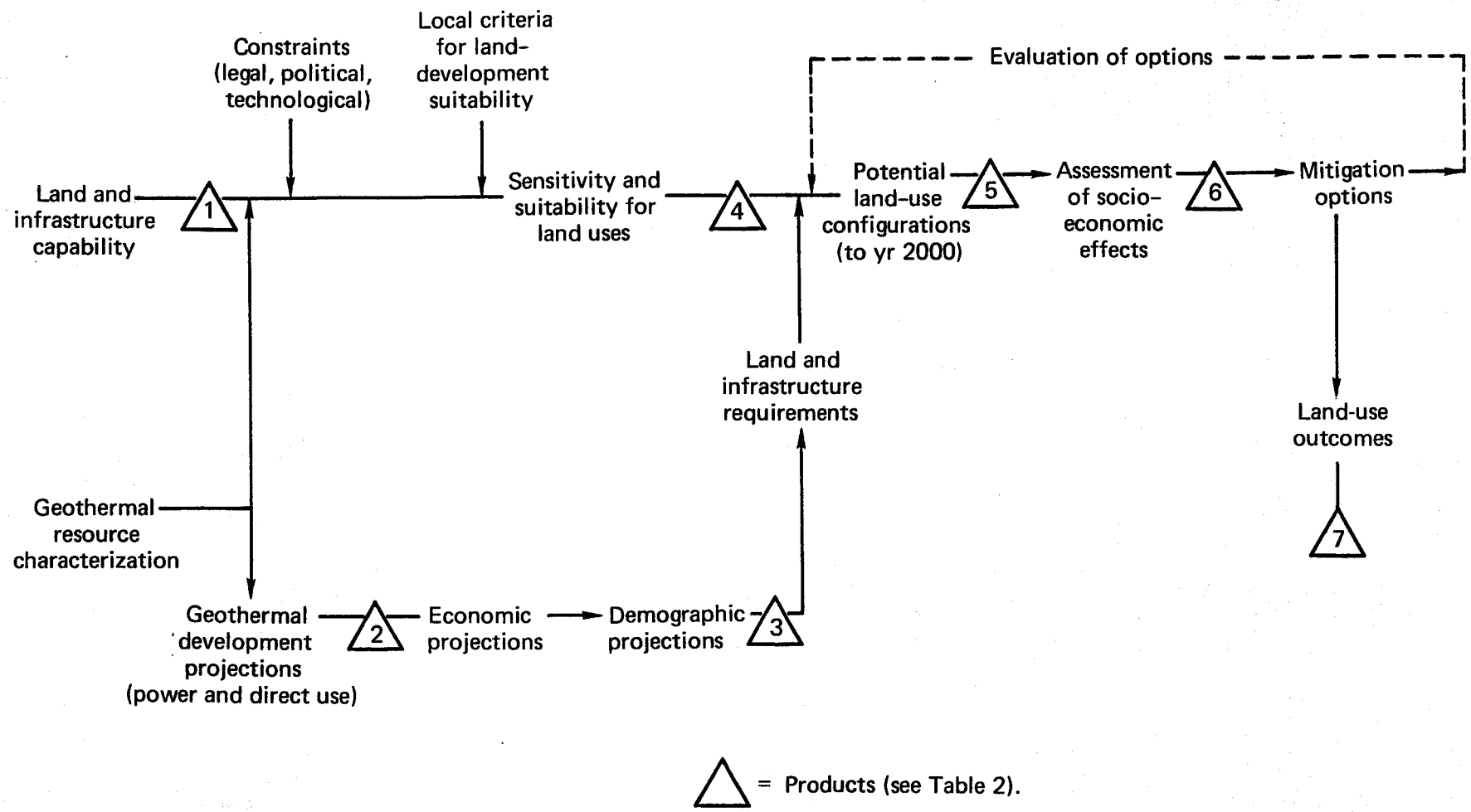

Figure 24. Initial work under the Socioeconomic Research Program consists of two parallel efforts: geothermal, economic, and demographic projections cover all four KGRA counties, while land-based analyses are limited to Lake County.

Work unit		Product responsibility
1. Land and infrastructure		
• Compile data on land sensitivity and infrastructure capacity from federal and local sources (see Appendix B);		LLL, GRIPS, counties
• Digitize source data;		LLL
• Develop maps of capability factors.	①	LLL
2. Projections of geothermal resource development		
• Characterize resource using published data;		LLL, LBL
• Develop alternative development projections for electric power and direct use;		LBL
• Prepare report.	②	LBL
3. Economic and demographic projections		
• Compile economic data for regional input-output model (see Appendix B);		LLL, GRIPS, counties
• Develop baseline projection based on no further geothermal development;		LLL
• Forecast direct and induced economic changes for each geothermal development projection;		LLL
• Assemble locally validated demographic data;		LBL, GRIPS, counties
• Forecast demographic changes for baseline and each geothermal development projection;		LBL
• Prepare report.	③	LLL, LBL
4. Constraints and criteria		
• Determine technological constraints on geothermal resource development (locations of type of resource, substations, etc.), digitize;		LLL, LBL
• Determine legal and local political constraints (land-use plans and controls, etc.);		LLL, GRIPS, counties
• Determine local criteria to evaluate land suitability for development (see sample, Appendix B).		LLL, GRIPS, counties
5. Suitability of land for development		
• Incorporate criteria determined in Work Unit 4 to "overlay" capability factors and constraints, construct map indicating areas sensitive to development and those suitable for each type of land use (geothermal, residential, industrial, etc.).	④	LLL
6. Potential land-use configurations		
• Forecast land and infrastructure demands in each geothermal resource development projection based on forecasts of economic and demographic changes (Work Unit 3);		LLL, GRIPS, counties
• Generate land-use configurations based on land suitability (Work Unit 5) and forecast demand (Work Unit 6).	⑤	LLL
7. Fiscal 1979 Annual Report		LLL
8. Socioeconomic assessments		
• Assess effects of geothermal resource development on		
– Land use and aesthetics,		LLL
– Economics,		LLL
– Demographic and social structure,		LBL
– Infrastructure and fiscal systems;		LLL, LBL
• Prepare assessment report.	⑥	LLL, LBL
9. Options for mitigation		
• Devise alternative policy options to mitigate adverse effects (see sample, Appendix B)		LLL, GRIPS, counties
• Program options for computer analysis, generate new land-suitability maps;		LLL
• Generate new land use configurations to assess impact of options (*Note*): the computer will allow iterations of steps in Work Unit 9 to test various combinations of options);		LLL
• Modify effects assessments for major changes in impacts resulting from alternative mitigating policies;		LLL, LBL
• Evaluate efficacy and effects of policy options.		LLL, GRIPS, counties
10. Land use outcomes		
• Prepare final land-use configurations for baseline and each geothermal development projection;		LLL
• Prepare accompanying text.	⑦	LLL, GRIPS, counties
11. Fiscal 1980 Annual Report		LLL

Table 2. Work units for the Socioeconomic Research Program for the Geysers-Calistoga KGRA.

and a dramatic increase in geothermal development activity. As a result, we were forced to write most of our report in a virtual absence of firm, clear local policy. On the other hand, it is no doubt fortunate that the data herein are made available at a time when land use policy in general, and geothermal policy, in particular, are undergoing extensive rethinking and revision.

One last point: although the remainder of the program covers all four counties in the KGRA, the land use component was limited to Lake County because we only had enough money for one, and for reasons explained earlier, Lake County was our top priority. However, the methodology and computer technology we used are not revolutionary, and any agency that so desired could, we are sure, duplicate part or all of the study for their own area of interest. Toward that end, we endeavored to make our own procedures as explicit as we could.

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