Title
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ABSTRACT

Riparian habitats in the California hardwoods zone are slowly being converted from natural landuses to permanently anthropogenic landuses. Riparian habitat is important for species diversity, water quality, and recreation. CA Department of Forestry and Fire Protection (CDF) Hardwoods Rangeland Monitoring Project's map of the riparian areas in the hardwoods zone was combined with the UCSB California Gap Analysis Managed Areas map to show the area of the riparian habitat in the study not protected from development. Using ARC/INFO GRID, it was found that, of the approximately 2,780,000 acres of riparian mapped by CDF, 65% is privately owned and not managed for biodiversity. A digital elevation model (DEM) was used to determine which riparian areas were on slopes of <10°. Riparian habitat on a slope of <10° and privately owned is at a higher risk of development and represents 35% of the total riparian habitat in the study area. In addition, to the management status and slope of the riparian hardwood habitat, the population growth rate of the study area counties was examined. The population of California is estimated to increase from 23,383,000 in 1996 to 47,507,000 by 2020, with 44% of the population growth expected in occur in the counties with riparian hardwood habitat. In order to protect the riparian habitat in the hardwoods zone, a coordinated effort between 42 counties in the hardwoods zone is needed.

INTRODUCTION

The alluvial terraces and riverbottoms of California were some of the first areas settled and farmed in California. This pattern began in earnest in the 1800's. Currently the Central Valley has been converted almost entirely to human uses. In the late 1980's the

riparian forests in the Central Valley were estimated to cover only 0.45% of the Valley, even though the floodplains cover 13.4% of the Valley (Hunter et al. submitted). What little remains of the riparian forests are for the most part privately owned and not managed for preservation or biological diversity. Is the trend found in the Central Valley also occurring in the hardwoods rangelands of the California foothills?

According to the California Department of Forestry and Fire Protection, Forest and Rangeland Resources Assessment Program (FRAP) the hardwood rangelands are characterized by four cover types: valley foothill hardwood, montane hardwoods, valley riparian and montane riparian. The valley foothill hardwood cover type consists of blue oak, valley oak, Englemann oak, line oak, coast live oak, canyon live oak, and sometimes digger pine. The montane hardwood cover type consists of canyon live oak, tanaok, madrone, California black oak, Oregon white oak, Douglas fir, ponderosa pine, redwood, white fir, Coulter and Jeffrey pine. The valley riparian cover type consists of cottonwood, California sycamore, valley oak, white alder, boxelder and Oregon ash. The montane riparian cover type consists of Black cottonwood, bigleaf maple, dogwood, boxelder quaking aspen, white alder, Oregon ash willow and thinleaf alder (California Department of Forestry and Fire Protection, 1988).

The hardwood zone significantly affects California's water quality, biodiversity, and recreation. Riparian areas provide a filtering system for the water passing through the hardwood zone. The diversity of riparian vegetation helps stabilize banks and reduces erosion during high water events. Riparian systems also play a role in aquifer recharge (Elmore, 1988).

In addition to its role in maintaining water quality, riparian systems are important habitats for many California vertebrate species. The hardwoods, including riparian areas, provide habitats for over 300 vertebrate species (Standiford et al., 1996). It is estimated that 25% of California's land mammals are dependent are riparian systems (Leopold, 1984). It is estimated that 83% of the amphibians and 40% of the reptiles in California are dependent on riparian systems for part or all of their life cycle (Brode and Bury, 1984).

Hardwood rangelands have been managed primarily for grazing since European settlement. Currently most of the riparian areas are on private land not managed for biodiversity. The lack of protection for hardwood riparian areas leaves them vulnerable to development. California's population in 1996 was estimated by the California Department of Finance to be 32,383,000 and is estimated to reach 47,507,000 by the year 2020. As the population increases, California is rapidly converting agricultural lands and wildlands to urban landuse. Without a coordinated landuse plan, the riparian hardwoods could become fragmented and degraded.

METHODS

Data Used:

The hardwoods riparian layer comes from the California Department of Forestry and Fire Protection's (CDF) Hardwoods Rangeland Monitoring Project. CDF contracted with Pacific Meridian Resources to produce a GIS layer that maps the hardwoods rangeland in California. The riparian vegetation map, one of the components of the CDF Hardwoods Rangeland Monitoring Project, is a raster-based data layer depicting a 375 meter buffer along perennial streams within the Pacific Meridian designated hardwoods study area. The classification for the buffered area is as follows:

1. riparian vegetation
2. hardwoods rangelands (<70% canopy)
3. shrub
4. conifer
5. herbaceous
6. water
7. other (including urban, marsh, rock, bare, etc.)

The grid size for the data is 25 meters. The full description of the GIS data set and the data accuracy assessment are available in "California Hardwood Rangeland Monitoring Final Report" by Pacific Meridian Resources (1994).

Riparian areas tend to be small patches, and a small grid cell size is necessary to capture as much information as possible. Therefore the 25 meter grid cell size was preserved because resampling at a larger grid cell size would generalize the data and information could be lost.

The managed areas data set is from the California Gap Analysis Managed Areas layer from University of California, Santa Barbara 1996. This layer depicts lands managed for long-term protection of biodiversity (Beardsley and Stoms 1993). In the 1996 metadata, management areas include the following:

1. Management Level 1: An area with an active management plan in operation that is essentially maintained in its natural state and within which natural disturbance events are either allowed to proceed without interference or are mimicked through management.
2. Management Level 2: Most non-designated public lands managed for multiple uses, including biodiversity. Legal mandates prevent permanent conversion to anthropogenic habitat types (with some exceptions, such as tree plantations) and confer protection to populations of federally listed and/or candidate species.
3. Mangement Level 3: Other private lands without existing easements or irrevocable management agreements that maintains native species and natural communities and which are managed primarily or exclusively for intensive human activity, such as lands used for urban or agricultural purposes.

Other information about the data is available in the UCSB California Gap Analysis Managed Areas metadata. The original data format is vector; for this analysis the data was converted to raster and the same gird size as the CDF hardwoods riparian map.

The Digital Elevation Model (DEM) that was used for slope data came from the 1:250,000 scale USGS DEM. The basic elevation model is produced by the Defense Mapping Agency (DMA), but is distributed by the USGS. The data was resampled at a 25 meter grid cell size. The DEM was converted to a slope grid using the ARC/INFO SLOPE command. The metadata is available on the USGS home page (http://edcwww.cr.usgs.gov/glis/hyper/guide/1_dgr_dem).

The population data is from the Demographic Research Unit of the California Department of Finance, with population statistics from 1996 to 2020. The interim population projections have been based on 1993 projections from the Department of Finance. More information is available from the California Department of Finance home page at http://www.dof.ca.gov/html/demograp/repndat.htm.

Analysis:

The data analysis was performed using the ARC/INFO GRID module. Two GRID commands (CON and ZONALSTATS) were used to calculate how much of the riparian area was contained in each management level and county. Once the analysis in GRID was complete, the tables were exported to Microsoft ACCESS and the conversion from square meters to acres was performed.

RESULTS

Riparian Habitat and Management Status

There are 2,780,000 acres of riparian hardwoods in the study area (Map 1). 10% of the riparian habitat is protected at Management Level 1, the highest level of protection, and is managed for biodiversity. 27% of the riparian habitat is protected at Management Level 2, which is managed for multiple uses and cannot be converted to permanent anthropogenic uses. 63% of the riparian habitat is classified as Management Level 3, which is not protected for biodiveristy and can potentially be converted to anthropogentic uses. The current protection status for riparian habitat within the sample area is summarized in the following table:

Protection Level 1	Riparian Area (acres)	280,000

Protection Level 2	Riparian Area (acres)	740,000
Protection Level 3	Riparian Area (acres)	1,750,000
Total Riparian in Study Area	Riparian Area (acres)	2,780,000

Riparian, Management Status and Slope

In the subsequent run, the slope of the riparian habitat was included. 51 % of the riparian area is located on a slope of >10°. 49% of the riparian area is on a slope < 10°.

Management	%> 10° slope	%< 10° slope
Management Level 1	65	35
Management Level 2	64	36
Management Level 3	43	57

57% of riparian in Management Level 3 can potentially be developed because it falls on a slope of less then 10 degrees. This is 35 % of the total riparian habitat in the study area.

Riparian Habitat, Management Status, Slope and County

There are 42 counties included in the study area (Map 2). The counties with the most riparian area in the study area are Mendocino and Monterery Counties. Each of these counties contains 7% of the riparian in the study area. In Mendocino County, 61% of the riparian habitat is found in areas of >10° slope. 35% of the riparian area in the study area is unprotected and on a slope of < 10°. Monterey County has 53% of its riparian area on a >10° slope and 47% on a < 10° slope. No one county has a large amount of the riparian habitat in the study area. Some of the counties have very little hardwood riparian habitat because the county has very little area in the hardwoods range. Because of the distribution of the riparian hardwoods, a coordinated effort between all the counties would be needed in order to protect the resource.

The counties can be split into how much riparian habitat is on a <> a 10° slope (Fig. 1)

Number of Counties	50% of hardwoods riparian area on a slope of:
20 Counties	<10°

22 Counties	>10°

Riparian Habitat, Management Status, Slope, County and Population Growth

California's population has been projected to increase from 32,383,000 in 1996 to 47,507,000 by 2020. Fresno County is the fastest growing county in the study area with an estimated average yearly increase in population of 26,000 from 1996-2000, 28,900 from 2000-2010 and 34,249 from 2010 - 2020. Fresno County contains 3.5% of the riparian habitat in the study area with 42% of it on a slope of < 10°. The slowest growing county in the study area is Sierra County, with a rate of less than 50 people per year. The county has approximately 0.2% of the riparian habitat in the study area (Fig 1). Overall the total growth projected for counties with oak hardwood riparian is 6,621,530 more people from 1996 to 2020.

CONCLUSION

The California riparian hardwoods are found in 42 counties with no single county containing a disproportionately large share of the total hardwoods habitat. In addition to the geographic region being extensive, riparian habitat is a linear feature that crosses many management boundaries, landuses, and ownerships. Because of the spatial distribution of this resource, it will require a coordinated effort between many agencies and local groups to protect a significant amount of the hardwoods riparian habitat.

California's increasing population, and the resulting increase in development, will result in a higher threat to unprotected riparian habitat. It is estimated that from 1996 to 2020 California's population will increase on average by 630,000 persons per year, with 44% of the population increase in the hardwoods zone counties. Currently 35% of the riparian habitat in the study area is privately owned and on a slope of <10°. Land that is on a slope of <10o historically has been the first to be developed because it does not require as much modification (Goldman, 1986). Currently around 35% of the hardwood riparian habitat has a protection level of 1 or 2. This leaves 65% of the hardwoods riparian area under the protection of local ordinances. In order to understand the threat to hardwood riparian habitat, more detailed analysis needs to be preformed incorporating county general plans and growth models.

Acknowledgments

Appendix A

Figure 1

ALAMEDA			CONTRA COSTA	
% of Riparian Study Area in County:	0.95		% of Riparian Study Area in County:	0.64
% of Riparian in County >10 slope:	52.8		% of Riparian in County >10 slope:	36.8
% of Riparian in County <10 slope:	47.1		% of Riparian in County <10 slope:	63.1
Average increase in population per year 96-00:	1410		Average increase in population per year 96-00:	1392
Average increase in population per year 00-10:	1260		Average increase in population per year 00-10:	1349
Average increase in population per year 10-20:	1128		Average increase in population per year 10-20:	1198
AMADOR			**EL DORADO**	
% of Riparian Study Area in County:	1.71		% of Riparian Study Area in County:	3.31
% of Riparian in County >10 slope:	24.7		% of Riparian in County >10 slope:	30.9
% of Riparian in County <10 slope:	75.2		% of Riparian in County <10 slope:	69
Average increase in population per year 96-00:	1312		Average increase in population per year 96-00:	4950
Average increase in population per year 00-10:	1330		Average increase in population per year 00-10:	4120
Average increase in population per year 10-20:	1380		Average increase in population per year 10-20:	4170
BUTTE			**FRESNO**	
% of Riparian Study Area in County:	3.8		% of Riparian Study Area in County:	3.54
% of Riparian in County >10 slope:	41.9		% of Riparian in County >10 slope:	58
% of Riparian in County <10 slope:	58		% of Riparian in County <10 slope:	41.9
Average increase in population per year 96-00:	3975		Average increase in population per year 96-00:	2610
Average increase in population per year 00-10:	4150		Average increase in population per year 00-10:	2890

Average increase in population per year 10-20:	4030	Average increase in population per year 10-20:	3424
CALAVERAS		**GLENN**	
% of Riparian Study Area in County:	3.2	% of Riparian Study Area in County:	1.53
% of Riparian in County >10 slope:	34.1	% of Riparian in County >10 slope:	83.3
% of Riparian in County <10 slope:	65.8	% of Riparian in County <10 slope:	16.6
Average increase in population per year 96-00:	2400	Average increase in population per year 96-00:	575
Average increase in population per year 00-10:	2270	Average increase in population per year 00-10:	740
Average increase in population per year 10-20:	2270	Average increase in population per year 10-20:	860
COLUSA		**HUMBOLDT**	
% of Riparian Study Area in County:	0.5	% of Riparian Study Area in County:	3.07
% of Riparian in County >10 slope:	66.8	% of Riparian in County >10 slope:	63.1
% of Riparian in County <10 slope:	33.1	% of Riparian in County <10 slope:	36.8
Average increase in population per year 96-00:	437.5	Average increase in population per year 96-00:	1350
Average increase in population per year 00-10:	530	Average increase in population per year 00-10:	1340
Average increase in population per year 10-20:	640	Average increase in population per year 10-20:	1260
KERN		**MARIPOSA**	
% of Riparian Study Area in County:	3.56	% of Riparian Study Area in County:	1.85
% of Riparian in County >10 slope:	69.2	% of Riparian in County >10 slope:	36.3
% of Riparian in County <10 slope:	30.7	% of Riparian in County <10 slope:	63.6
Average increase in population per year 96-00:	2567	Average increase in population per year 96-00:	512.5
Average increase in population per year 00-10:	2315	Average increase in population per year 00-10:	460
Average increase in population per year 10-20:	2620	Average increase in population per year 10-20:	450
KINGS		**MENDOCINO**	
% of Riparian Study Area in County:	2.31	% of Riparian Study Area in County:	7.85
% of Riparian in County >10 slope:	51.4	% of Riparian in County >10 slope:	61.4
% of Riparian in County <10 slope:	48	% of Riparian in County <10 slope:	38.5
Average increase in population per year 96-00:	3525	Average increase in population per year 96-00:	1650
Average increase in population per year 00-10:	3450	Average increase in population per year 00-10:	1880
Average increase in population per year 10-20:	3850	Average increase in population per year 10-20:	1880
LAKE		**MERCED**	
% of Riparian Study Area in County:	3.58	% of Riparian Study Area in County:	0.29
% of Riparian in County >10 slope:	60.6	% of Riparian in County >10 slope:	50.6
% of Riparian in County <10 slope:	39.3	% of Riparian in County <10 slope:	49.3
Average increase in population per year 96-00:	1925	Average increase in population per year 96-00:	5525

Average increase in population per year 00-10:	1830	Average increase in population per year 00-10:	7380
Average increase in population per year 10-20:	1870	Average increase in population per year 10-20:	8580
MADERA		**MONTEREY**	
% of Riparian Study Area in County:	1.41	% of Riparian Study Area in County:	7.66
% of Riparian in County >10 slope:	33.9	% of Riparian in County >10 slope:	53.2
% of Riparian in County <10 slope:	66	% of Riparian in County <10 slope:	46.7
Average increase in population per year 96-00:	3500	Average increase in population per year 96-00:	5250
Average increase in population per year 00-10:	3770	Average increase in population per year 00-10:	7190
Average increase in population per year 10-20:	4120	Average increase in population per year 10-20:	8590
MARIN		**NAPA**	
% of Riparian Study Area in County:	1.04	% of Riparian Study Area in County:	1.7
% of Riparian in County >10 slope:	48.7	% of Riparian in County >10 slope:	50.5
% of Riparian in County <10 slope:	51.2	% of Riparian in County <10 slope:	49.4
Average increase in population per year 96-00:	550	Average increase in population per year 96-00:	1075
Average increase in population per year 00-10:	120	Average increase in population per year 00-10:	1640
Average increase in population per year 10-20:	-330	Average increase in population per year 10-20:	910
NEVADA		**SAN LUIS OBISPO**	
% of Riparian Study Area in County:	2.55	% of Riparian Study Area in County:	4.79
% of Riparian in County >10 slope:	28	% of Riparian in County >10 slope:	35.7
% of Riparian in County <10 slope:	71.9	% of Riparian in County <10 slope:	64.2
Average increase in population per year 96-00:	3175	Average increase in population per year 96-00:	4100
Average increase in population per year 00-10:	2860	Average increase in population per year 00-10:	4490
Average increase in population per year 10-20:	2760	Average increase in population per year 10-20:	4400
PLACER		**SAN MATEO**	
% of Riparian Study Area in County:	1.65	% of Riparian Study Area in County:	0.91
% of Riparian in County >10 slope:	43.1	% of Riparian in County >10 slope:	39.8
% of Riparian in County <10 slope:	56.8	% of Riparian in County <10 slope:	60.1
Average increase in population per year 96-00:	6600	Average increase in population per year 96-00:	6600
Average increase in population per year 00-10:	6630	Average increase in population per year 00-10:	5850
Average increase in population per year 10-20:	5660	Average increase in population per year 10-20:	4450
SACRAMENTO		**SANTA BARBARA**	
% of Riparian Study Area in County:	1.68	% of Riparian Study Area in County:	5.61
% of Riparian in County >10 slope:	1.77	% of Riparian in County >10 slope:	59.4
% of Riparian in County <10 slope:	98.1	% of Riparian in County <10 slope:	40.5

Average increase in population per year 96-00:	2515	Average increase in population per year 96-00:	5475
Average increase in population per year 00-10:	2530	Average increase in population per year 00-10:	5310
Average increase in population per year 10-20:	2535	Average increase in population per year 10-20:	5250
SAN BENITO		**SANTA CLARA**	
% of Riparian Study Area in County:	1.68	% of Riparian Study Area in County:	2.79
% of Riparian in County >10 slope:	48.5	% of Riparian in County >10 slope:	59.7
% of Riparian in County <10 slope:	51.4	% of Riparian in County <10 slope:	40.2
Average increase in population per year 96-00:	1500	Average increase in population per year 96-00:	1742
Average increase in population per year 00-10:	1620	Average increase in population per year 00-10:	1687
Average increase in population per year 10-20:	1680	Average increase in population per year 10-20:	1401
SAN JOAQUIN		**SANTA CRUZ**	
% of Riparian Study Area in County:	0.1	% of Riparian Study Area in County:	0.94
% of Riparian in County >10 slope:	56	% of Riparian in County >10 slope:	39
% of Riparian in County <10 slope:	43.9	% of Riparian in County <10 slope:	60.9
Average increase in population per year 96-00:	1310	Average increase in population per year 96-00:	4500
Average increase in population per year 00-10:	1599	Average increase in population per year 00-10:	3220
Average increase in population per year 10-20:	1754	Average increase in population per year 10-20:	3290
SHASTA		**TEHAMA**	
% of Riparian Study Area in County:	4.39	% of Riparian Study Area in County:	6.5
% of Riparian in County >10 slope:	43.6	% of Riparian in County >10 slope:	58.2
% of Riparian in County <10 slope:	56.3	% of Riparian in County <10 slope:	41.7
Average increase in population per year 96-00:	4200	Average increase in population per year 96-00:	1075
Average increase in population per year 00-10:	3460	Average increase in population per year 00-10:	920
Average increase in population per year 10-20:	3390	Average increase in population per year 10-20:	980
SIERRA		**TRINITY**	
% of Riparian Study Area in County:	0.21	% of Riparian Study Area in County:	1.61
% of Riparian in County >10 slope:	53.3	% of Riparian in County >10 slope:	63.3
% of Riparian in County <10 slope:	46.6	% of Riparian in County <10 slope:	36.6
Average increase in population per year 96-00:	7.5	Average increase in population per year 96-00:	187.5
Average increase in population per year 00-10:	40	Average increase in population per year 00-10:	210
Average increase in population per year 10-20:	20	Average increase in population per year 10-20:	180
SOLANO		**TULARE**	
% of Riparian Study Area in County:	0.21	% of Riparian Study Area in County:	3.48
% of Riparian in County >10 slope:	39.1	% of Riparian in County >10 slope:	67.4

% of Riparian in County <10 slope:	60.8	% of Riparian in County <10 slope:	32.5
Average increase in population per year 96-00:	1302	Average increase in population per year 96-00:	8575
Average increase in population per year 00-10:	7770	Average increase in population per year 00-10:	1040
Average increase in population per year 10-20:	6270	Average increase in population per year 10-20:	1201
SONOMA		**TUOLUMNE**	
% of Riparian Study Area in County:	4.54	% of Riparian Study Area in County:	2.19
% of Riparian in County >10 slope:	48.3	% of Riparian in County >10 slope:	40.4
% of Riparian in County <10 slope:	51.6	% of Riparian in County <10 slope:	59.5
Average increase in population per year 96-00:	6400	Average increase in population per year 96-00:	1550
Average increase in population per year 00-10:	7030	Average increase in population per year 00-10:	1480
Average increase in population per year 10-20:	4840	Average increase in population per year 10-20:	1490
STANISLAUS		**VENTURA**	
% of Riparian Study Area in County:	0.41	% of Riparian Study Area in County:	2.59
% of Riparian in County >10 slope:	62.2	% of Riparian in County >10 slope:	56.5
% of Riparian in County <10 slope:	37.7	% of Riparian in County <10 slope:	43.4
Average increase in population per year 96-00:	1470	Average increase in population per year 96-00:	1015
Average increase in population per year 00-10:	1511	Average increase in population per year 00-10:	1307
Average increase in population per year 10-20:	1652	Average increase in population per year 10-20:	1370
YOLO		**YUBA**	
% of Riparian Study Area in County:	0.16	% of Riparian Study Area in County:	1.27
% of Riparian in County >10 slope:	68.2	% of Riparian in County >10 slope:	27
% of Riparian in County <10 slope:	31.7	% of Riparian in County <10 slope:	72.9
Average increase in population per year 96-00:	5000	Average increase in population per year 96-00:	1500
Average increase in population per year 00-10:	4420	Average increase in population per year 00-10:	1880
Average increase in population per year 10-20:	4570	Average increase in population per year 10-20:	2370

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