Summary Brief

Napa County Conservation Policy
Existing Conditions and Proposed Policy Impacts

March 22, 2019
Amber Manfree Consulting

Napa County, California, currently has over 50,000 acres of productive agricultural land, mostly planted in premium wine grapes. The Napa Valley floor has been essentially built-out following replanting of other crops to vineyard over the past few decades. This has resulted in economic and social pressures to expand vineyard acreage by converting wildlands. Overarching contemporary issues of climate change and biodiversity loss call this practice into question, as Napa County wine grape production is expected to be negatively impacted by climate change, and as the region is a biodiversity hotspot by virtue of its California Floristic Province location.

In order to inform the discussion of how to best respond to this situation, estimates have been made of developable area under existing policies and under several suggested policy alternatives in order to compare possible outcomes. Scientific research shows that leaving wildlands intact is an effective way to retain carbon, protect water supplies, and support biodiversity. Policies that achieve this goal are recommended.

Key Findings

1. **Mitigating on slopes.** The most significant policy factor affecting the ratio of conservation to development is whether or not conservation credit ("mitigation" or "retention") is allowed on lands not at risk of development (undevelopable lands; e.g., with slopes greater than 30%).

   Recommendation: Increase effective conservation by requiring that mitigation be done on site and on land that is at risk of development.

2. **Tree Canopy.** County-wide analysis of land cover and developable area on a per-parcel basis estimates suggests:

   - A 3:1 mitigation policy where mitigation is allowed on undevelopable land would increase county-wide canopy protection by 4% over current conditions, leaving more than 27,800 acres of canopy - predominantly oaks - at-risk of deforestation.
   - A 2:1 mitigation policy without mitigation on undevelopable land would increase canopy protection by 12% over current conditions, leaving about 14,600 acres of canopy at risk of deforestation.
   - A 3:1 mitigation policy without mitigation on undevelopable land would increase canopy protection by 14% over current conditions, leaving about 10,900 acres of canopy at-risk of deforestation.

   Recommendation: For all canopy, require at least 3:1 mitigation on-site, with no mitigation on undevelopable areas.

3. **Shrubland.** County-wide 40% shrubland retention will have virtually no conservation benefit if conservation credit is allowed in undevelopable land. This is because most parcels with development potential contain significant area with slopes over 30% and/or streams, which is already precluded from development by the Hillside Ordinance.

   ***Recommendation*:** Require that all shrubland retention be done on developable areas.

4. **Water supply.** Increased tree canopy retention will offer improvement in water security. In several sensitive domestic water supply drainages, grass and shrub are extensive land cover types, so canopy protections alone will not dramatically change development patterns. At least four of seven reservoirs have had, or currently have, sediment loading issues due to sources more than 500 feet away, and algae issues related to nutrient loading are an emerging concern. Linear setbacks (buffers) proposed for water supply reservoirs are unlikely to protect water supplies, because pollutant delivery is a function of the rate of a waterway's energy dissipation against its bed and banks of per unit downstream length, not linear distance across a landscape.

   ***Recommendation*:** In addition to maximizing tree protection, retain shrub and grasslands in water supply watersheds. Hydrologic analysis and ongoing monitoring is needed to ensure water quality objectives are met. A hydrologic model, informed by field data, is the established method for evaluating watershed development impacts.

5. **Urgency.** The Intergovernmental Panel on Climate Change states that "rapid, far-reaching and unprecedented changes in all aspects of society" will be required to limit global warming to 1.5°C. Preventing further loss of wildlands is a key short-term climate stabilization strategy, one of numerous actions needed to buffer the worst climate change impacts.

   ***Recommendation*:** Retaining more natural resources by limiting the conversion of wildland to other uses keeps climate management options open.

Napa County Conservation Policy
Existing Conditions and Proposed Policy Impacts

Analysis prepared for Napa Growers / Vintners for Responsible Agriculture
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> "…wine's future is tied inextricably to a vital Earth and a vital population. Grape growers and winemakers must understand both the dire condition of the planet and the small, but significant, role their industry holds in the human matrix. They must seek, therefore, in a responsible manner, their proper and effective role in the adaptation to and the mitigation of global climate change. The future of the wine industry is dependent upon an effective course of action. The Romans declared, "Vino veritas," or "in wine there is truth (Jones and Webb, 2010)." The simple, yet tragic, truth is the Earth's climate is changing. How the wine industry responds will determine if the industry is to survive."
>
> - Michelle Renée Mozell 2014

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Contents

Executive Summary

Napa County, California, currently has over 50,000 acres of productive agricultural land, mostly planted in premium wine grapes. The Napa Valley has been essentially built-out following conversions of other crops to vineyard over the past few decades, resulting in economic and social pressure to expand vineyard acreage by converting wildlands. Overarching contemporary issues of climate change and biodiversity loss call this practice into question, as Napa County wine grape production is expected to be negatively impacted by climate change, and as the region is a biodiversity hotspot by virtue of its California Floristic Province location.

In order to inform the discussion of how to best respond to this situation, estimates have been made of developable area under existing policy and under several policy alternatives to compare possible outcomes. Scientific research shows that leaving wildlands intact is an effective way to retain carbon, protect water supplies, and support biodiversity, so policies that achieve this goal are recommended.

Key Findings

1. **Mitigating on slopes.** The most significant policy factor affecting the ratio of conservation to development is whether or not conservation credit ("mitigation" or "retention") is allowed on lands not at risk of development (undevelopable lands; e.g., with slopes greater than 30%).

   ***Recommendation*:** Increase effective conservation by requiring that mitigation be completed on site and on land that is at risk of development.

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   - A 3:1 mitigation policy where mitigation is allowed on undevelopable land would increase county-wide canopy protection by 4% over current conditions, leaving more than 27,800 acres of canopy - predominantly oaks - at-risk of deforestation.

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2. **Water supply.** Increased tree canopy retention will offer improvement in water security. In several sensitive domestic water supply drainages, grass and shrub are extensive land cover types, so canopy protections alone will not dramatically change development patterns. At least four of seven reservoirs have had, or currently have, sediment loading issues due to sources more than 500 feet away, and algae issues related to nutrient loading are an emerging concern. Linear setbacks (buffers) proposed for water supply reservoirs are unlikely to protect water supplies, because pollutant delivery is a function of the rate of a waterway's energy dissipation against its bed and banks of per unit downstream length, not linear distance across a landscape.

   Recommendation: In addition to maximizing tree protection, retain shrub and grasslands in water supply watersheds. Hydrologic analysis and ongoing monitoring is needed to ensure water quality objectives are met. A hydrologic model, informed by field data, is the established method for evaluating watershed development impacts.

3. **High-value agriculture.** Climate change is predicted to shift premium grape growing regions toward the coast and northward away from Napa.

   ***Recommendation*:** Storing carbon in trees and soil to slow climate change impacts is one step toward protecting existing high-value crops. Transition Napa's winegrowing industry from a growth mode to a sustainability mode.

4. **Urgency.** The Intergovernmental Panel on Climate Change states that "rapid, far-reaching and unprecedented changes in all aspects of society" will be required to limit global warming to 1.5°C. Preventing further loss of forest and shrublands is a key short-term climate stabilization strategy; one of numerous actions needed to buffer the worst climate change impacts.

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Introduction

Napa County's pleasant Mediterranean climate and robust economy attract residents and tourists, and the economic potential of its agriculture continues to compel developers to convert wildlands to agriculture and sprawling estates. The County's wildlands possess tremendous biodiversity and natural beauty and they provide valuable ecological services such as clean drinking water, clean air, and carbon storage. For all these reasons, wildlands merit conservation and preservation. Many acres of wildlands have already been converted to vineyard and other uses. Symptoms of extensive land conversion and poor management, such as reduced aquatic ecosystem function, persist even after massive restoration efforts and nearly 30 years of well-intentioned local conservation policies. The pressures of preservation and wise use of resources are in constant tension, and projected climate change impacts elevate the need for thoughtful science-based decision-making.

The purpose of this study is to explore potential land-availability scenarios. County-wide land use and land cover are paired with a mathematical model to clarify current land availability and explore future availability under different policies. Differences in required conservation and allowed development under various constraints are estimated with existing and custom data.

A base model was developed which describes the maximum area currently available for agricultural or other permitted development. The base model answers the question, "What could be developed given current land cover constraints and policy?" Total estimated county-wide developable[1] land area is about 85,500 acres before considering 2:1 Mitigation and sixty-forty "60/40" retention policies, and about 75,900 acres after considering them (section 2). The base estimate is qualified by dividing it into categories of soil quality, vegetation cover type, and Land Use Zoning. Figures presented in this report are estimates. The model does not assess development likelihood or practical limitations such as water supply, remoteness, or climate.

This report is a starting point for policy discussion, and should be considered in tandem with contextual information, such as climate change literature, biodiversity literature, etc. The conservation summary provided in Center for Biological Diversity comments to the Napa County Board of Supervisors (2019) is a helpful reference. Economic impacts of policies, interactions with policies other than 2:1 Mitigation requirements and 60/40 retention, and assessments of habitat value should be considered as well.

1. The term "developable" is used in this report to signify areas that are not precluded from conversion to agriculture or other Land Use Zone-appropriate use by an existing use or existing policy. Lands which are precluded from development are referred to as "undevelopable."

Section 1 - Quick Reference & Existing Conditions

Quick reference. Approximate areas of conditions for all of Napa County are listed below. All figures are in acres.

Napa County
(Napa County 2004)

Total area	507,440
Land area	481,320

Model Estimates
(Manfree 2019)

Base developable area	85,500
Developable area less 2:1 policy	76,500
Developable area less 2:1 and 60/40	75,900

Slope
(Napa County 2002)

Total area < 30% slope	276,540
Land area < 30% slope	250,880
Land area < 30% slope, less estuarine wetlands	240,040
Land area > 30% slope	230,440

Reserves (fee title)
(GreenInfo Network 2018)

Federal	42,996
State	43,260
County	920
City	10,082
Special District	5,534
Non-profit	9,438
Total reserve area	133,116
Land area of reserves	112,229

Easements

Napa Land Trust (wildlands)	24,805
Other	4,196

Farmland Type
(CDC 2016)

Farmland	75,570
Grazing land	179,330
Other undeveloped	204,830

Vegetation - countywide
(Thorne 2004)

Oak woodlands	148,828
Broadleaf (non-oak)	20,248
Conifer	38,601
Total canopy	207,677
Shrubland	61,244
Grassland	51,762

Other land cover
(Manfree 2018, Napa County 2016)

Existing vineyard	50,680
Stream setbacks	26,650
Lake Berryessa	19,080
Other water bodies	16,293
Roads	17,321
Railroad	332

Land Cover and Land Use

Tables detailing countywide existing vineyard (table 1), farmland type (table 2), and land cover (vegetation) (table 3) provide an overview of existing conditions. For an explanation of the minor discrepancies in total areas between tables, see the methods section and appendices. Current vineyard acreage is concentrated in the Agricultural Preserve zone, particularly on the floor of Napa Valley (figure 1).

Table 1. Countywide Existing Vineyard per Land Use Zone

(Data: Manfree 2018, Napa County 2013; 2016)

Land Use Zone	Zone Total Acres	Vineyard Acres	Percent Vineyard
Agricultural Watershed	422,905	24,196	6%
Agricultural Preserve	31,594	20,587	65%
Agricultural Watershed, Airport Compatibility	19,305	3,611	19%
Municipal/ urban	21,285	1,708	8%
Residential Country	3,263	486	15%
Residential	953	23	2%
Industrial Park, Airport Compatibility	1,092	16	1%
Residential Country, Urban Reserve	103	12	11%
Agricultural Preserve, Historic Restaurant	16	10	63%
Residential, Urban Reserve	319	3	1%
Planned Devel, Affordable Housing, Airport Compatibility	46	3	6%
Public Lands	29	3	10%
Local Commercial	127	2	2%
Airport	833	1	0%
Commercial Neighborhood	81	0	0%
Local Commercial, other	3	0	6%
Planned Development	1,868	0	0%
Other Zones	2,770	0	0%
Total:	**506,592**	**50,661**	**10%**

Farmland Type by Land Use Zone

Table 2. Countywide Farmland Type by Land Use Zone

See Appendix 1 for description of categories (Data: CDC 2016, Napa County 2013).

	Farmland Type - Higher Quality Farmland								
Land Use Zone	**Local importance**	**Statewide importance**	**Prime**	**Unique**	**Grazing**	**Other**	**Urban**	**Water**	**Total Acres**
Ag Watershed (AW)	13,686	5,135	7,583	13,340	171,238	186,939	2,071	21,897	**421,890**
Ag Preserve (AP)	1,060	1,742	20,571	1,811	629	4,671	1,109		**31,593**
Municipal/ urban (MU)	1,486	667	1,212	87	1,004	2,498	14,244	87	**21,285**
AW, Airport Compatibility (AC)	848	2,026	759	1,461	3,978	7,873	1,081	1,278	**19,303**
Residential Country (RC)	101	74	329	99	690	847	1,123		**3,263**
Planned Development (PD)	19	1	22		60	390	1,340	36	**1,868**
Industrial Park, AC	528	1	19		19	4	521		**1,092**
Residential (R)	1	3	9		40	175	724		**953**
AW, Skyline Wilderness Park	46				853	43			**943**
Airport	283	12			7	81	450		**833**
R, Urban Reserve (UR)						49	270		**319**
General Industrial, AC	56				8	53	186		**304**
Industrial	4				8	199	70		**281**
Public Lands, AC	31	128	83		3	13	6		**263**
Industrial, AC	70				2	7	123		**202**
PD, AC						25	143		**169**
R, AC	2				26	12	76	42	**157**
Local Commercial	24		2		13	8	80		**127**
AW, UR						110	2		**112**
Residential Country, UR	31	13			5	18	37		**103**
Commercial Neighborhood (CN)	7				31		43		**81**
Marine Commercial (MC), AC	0				9	13	39	15	**76**
AW, Affordable Housing (AH)	12				59		2		**73**
Napa Pipe Mixed Use R					1		44	11	**56**
Napa Pipe Industrial/Business Park							41	10	**51**
PD, AH, AC		3				36	7		**46**
Public Lands			4			11	14		**29**
Residential Country, AH	22				1				**23**
PD, AH			8			1	10		**20**
AP, Historic Restaurant			15			1			**16**
MC	1				2	1	10		**14**
MC, AH					11		2		**13**
AW, Produce Stand						4			**4**
Local Commercial, other						3			**3**
Local Commercial, AH					3				**3**
Local Commercial, AC	2								**2**
CN, UR							2		**2**
Total Acres:	**18,321**	**9,804**	**30,616**	**16,800**	**178,700**	**204,086**	**23,873**	**23,375**	**505,575**

Land Cover Type by Land Use Zone

Table 3 (Part 1 of 2). Countywide Land Cover Type by Land Use Zone

See Appendix 2 for description of categories (Data: Napa County 2013, Thorne 2004)

Land Use Zone	Oak	Broadleaf non-oak	Conifer	Grasslands	Chaparral	Serpentine	Rock outcrop
Agricultural Watershed	141,385	18,721	36,276	42,377	60,173	53,403	1,720
Agricultural Preserve	2,920	313	350	861	1	3	9
Municipal/ urban	1,317	566	342	2,411	42	15	
Agricultural Watershed, Airport Compatibility	1,329	265	1,273	4,940	373		
Residential Country	825	38	86	262	28		
Planned Development	335	15	73	32	67	26	2
Industrial Park, Airport Compatibility	16	3		176			
Residential	171	4	118	2	3		
Agricultural Watershed, Skyline Wilderness Park	316	311		179	94		
Airport	4		4	125			
Residential, Urban Reserve	35	1		6			
General Industrial, Airport Compatibility	4			54			
Industrial	65			0	13		
Public Lands, Airport Compatibility	1			0			
Industrial, Airport Compatibility				2			
Planned Development, Airport Compatibility			42		1		
Residential, Airport Compatibility				17			
Local Commercial	18	5	1	3			
Agricultural Watershed, Urban Reserve	1			98			
Unclassified				1			
Residential Country, Urban Reserve	5	5					
Commercial Neighborhood	34		2	4			
Marine Commercial, Airport Compatibility				17			
Agricultural Watershed, Affordable Housing	40			20		1	
Planned Development, Affordable Housing, Airport Compatibility			31				
Public Lands							
Residential Country, Affordable Housing	2						
Planned Development, Affordable Housing			3				
Agricultural Preserve, Historic Restaurant							
Marine Commercial				1		3	
Marine Commercial, Affordable Housing	3				4		
Agricultural Watershed, Produce Stand				4			
Local Commercial, other							
Local Commercial, Affordable Housing	1			2			
Local Commercial, Airport Compatibility							
Commercial Neighborhood, Urban Reserve							
Total Acres:	**148,828**	**20,248**	**38,601**	**51,597**	**60,800**	**53,452**	**1,730**

Table 3 (Part 2 of 2). Countywide Land Cover Type by Land Use Zone

Land Use Zone	Agriculture (grazing)	Urban	Water	Wetland	Vacant	No ID	Total Acres
Agricultural Watershed	29,905	6,148	25,675	2,326	798	1,412	**420,319**
Agricultural Preserve	25,336	1,323	359	38	45	36	**31,594**
Municipal/ urban	3,510	11,765	359	150	777	26	**21,281**
Agricultural Watershed, Airport Compatibility	3,965	1,893	2,194	2,094	6	79	**18,411**
Residential Country	527	1,481	6	6	4		**3,263**
Planned Development	20	1,156	36	6	99		**1,868**
Industrial Park, Airport Compatibility	703	152		42			**1,092**
Residential	19	636					**953**
Agricultural Watershed, Skyline Wilderness Park	9	20	9	3			**943**
Airport	85	587		28			**833**
Residential, Urban Reserve	7	255			16		**319**
General Industrial, Airport Compatibility	43	171		13	19		**304**
Industrial		196		6			**281**
Public Lands, Airport Compatibility	254			9			**263**
Industrial, Airport Compatibility	15	165	2	17			**202**
Planned Development, Airport Compatibility		126					**169**
Residential, Airport Compatibility	5	42	67	16	11		**157**
Local Commercial	33	63		2	2		**127**
Agricultural Watershed, Urban Reserve		13					**112**
Unclassified		82	21	3			**107**
Residential Country, Urban Reserve	50	43					**103**
Commercial Neighborhood	6	36					**81**
Marine Commercial, Airport Compatibility		29	31				**76**
Agricultural Watershed, Affordable Housing		8	1	3			**73**
Planned Development, Affordable Housing, Airport Compatibility	5	9					**46**
Public Lands	25		2	1			**29**
Residential Country, Affordable Housing	21						**23**
Planned Development, Affordable Housing		17					**20**
Agricultural Preserve, Historic Restaurant	14		1				**16**
Marine Commercial		9					**14**
Marine Commercial, Affordable Housing		6					**14**
Agricultural Watershed, Produce Stand							**4**
Local Commercial, other	3						**3**
Local Commercial, Affordable Housing		1					**3**
Local Commercial, Airport Compatibility		2					**2**
Commercial Neighborhood, Urban Reserve		2					**2**
Total Acres:	**64,561**	**26,437**	**28,763**	**4,762**	**1,777**	**1,554**	**503,109**

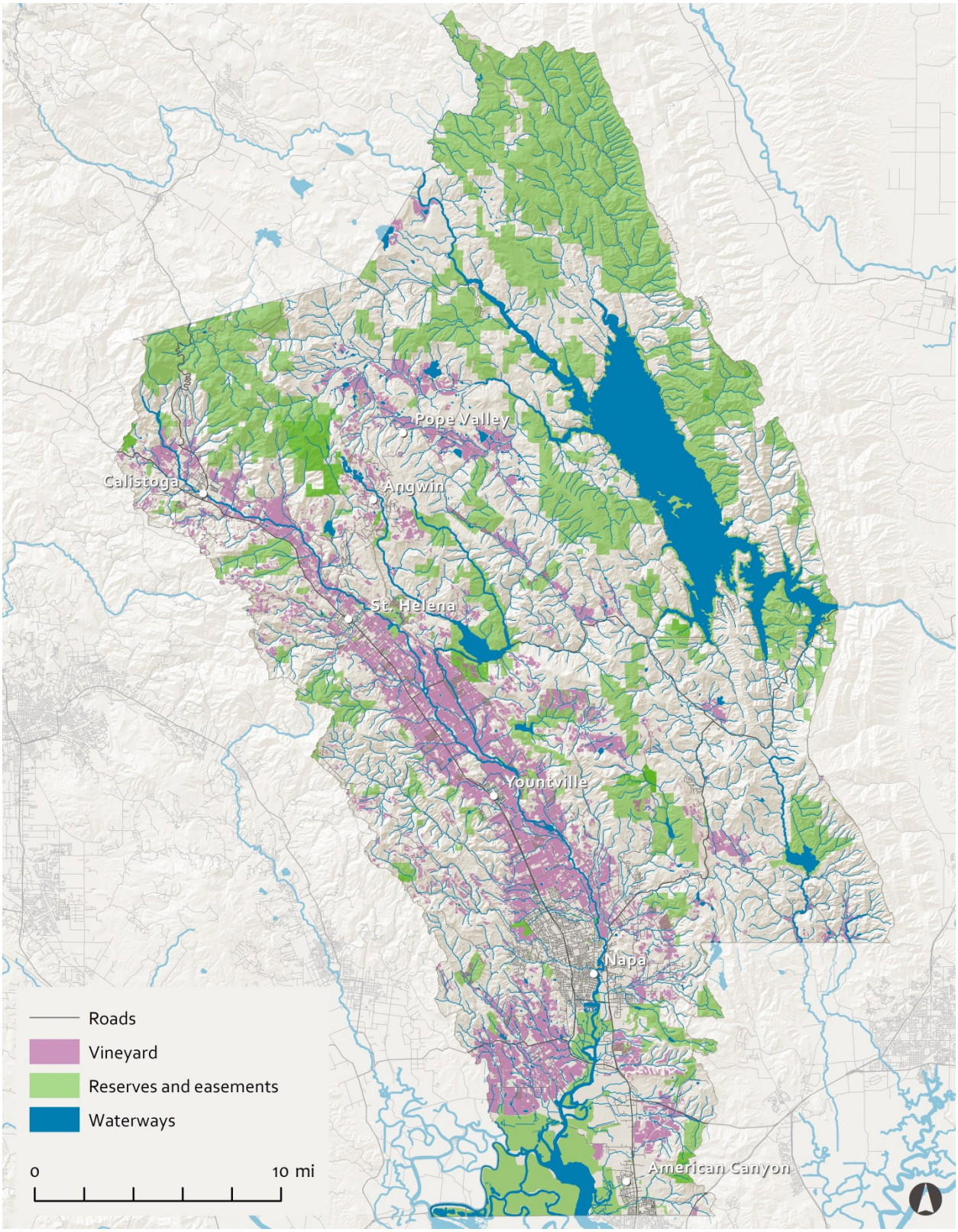


Figure 1. Napa County reference map.

Section 2 - Results of Policy Proposal Options Analysis

Existing Conditions Model Base

Several policies govern conversion of wildlands to vineyard in Napa County:

> **CEQA**. The California Environmental Quality Act (CEQA) requires evaluation of any potentially significant impacts a project may have on the environment and avoidance of, or mitigation for, those impacts. This includes habitat for species with threatened, endangered, rare, and special concern status (State of California 1970).
>
> **Oak Woodland Mitigation**. In 2004, CEQA was amended to require counties to determine whether conversion of oak woodlands to other uses will have a significant impact on the environment. In Napa, significant oak woodland impacts are typically mitigated on a two-to-one basis, preferably on-site, though off-site mitigation is allowed (State of California 2004).
>
> **Hillside Ordinance**. Napa County's Hillside Ordinance went into effect in 1993 in response to erosion problems associated with hillside development (County of Napa 1991). This ordinance:
>
> - Requires stream setbacks with widths correlating to adjacent percent slope
> - Discourages development on slopes over 30%, requiring exceptions to policy for such projects.
> - In sensitive domestic water supply drainages, wildland conversion projects must retain a minimum of 60% tree canopy and 40% shrubland on-site. Retention credit is allowed on slopes over 30% and within stream setbacks and adjacent parcels having the same owner may be handled as a single area when considering where to count retention.

Countywide developable lands total about 85,500 acres before applying the 2:1 oak retention or replacement rule and the 60/40 retention policy. After applying these rules, about 75,900 acres remain in the "developable" category, assuming landowners maximize their opportunity to count canopy or shrubs on undevelopable areas (such as slopes over 30% and stream setbacks) toward conservation goals and mitigation is done on-site. This is an approximation of existing conditions, issued as a base for policy analysis.

The base model for developable area was determined by starting with the total area of Napa County and subtracting areas precluded from conversion to agriculture or other uses due to regulations, existing uses, open water, or unsuitable soils. Estimates of developable area in different tables vary slightly due to secondary datasets that the base model is combined with (see methods and appendices 1 and 2). The largest undevelopable areas include lands over 30 percent slope, open water, reserves, and existing agriculture. Tables 4- 6, and Figures 2-3 show areas from the base model, before applying 2:1 and 60/40 policies.

Table 4. Developable land base model: Land Use Zone and California Department of Conservation Farmland Suitability Class.

See Appendix 1 for description of categories (Data: Manfree 2018, Napa County 2013, CDC 2016)

Land Use Zone	Higher Quality Farmland	Grazing land	Other land	Urban	Total Acres
Agricultural Watershed	8,321	39,569	26,474	369	**74,734**
Agricultural Watershed, Airport Compatibility	866	1,665	1,401	103	**4,035**
Agricultural Preserve	736	337	1,317	88	**2,478**
Municipal/ urban	811	240	757	358	**2,167**
Residential Country	70	169	244	78	**560**
Industrial Park, Airport Compatibility	401	16	3	37	**456**
Public Lands, Airport Compatibility	233	3	9	3	**248**
Planned Development	22	10	106	87	**225**
Agricultural Watershed, Urban Reserve	0		86	0	**86**
Other Zones	119	63	129	108	**419**
Total Acres	**11,579**	**42,073**	**30,526**	**1,231**	**85,408**

Table 5. Developable land base model: Land Use Zone and land cover type.

See Appendix 2 for description of categories (Data: Manfree 2018, Napa County 2013, Thorne 2004)

Land Use Zone	Oak	Broadleaf non-oak	Conifer	Grasslands	Chaparral	Agriculture (grazing)	No ID	Vacant	Wetland vegetation	Total Acres
Agricultural Watershed	31,589	3,025	5,659	18,129	9,513	6,020	282	315	287	**74,819**
Agricultural Watershed, Airport Compatibility	572	45	652	1,745	163	830	21		12	**4,040**
Agricultural Preserve	857	68	86	469		953	9	14	24	**2,479**
Municipal/ urban	345	201	65	785	2	588	6	142	38	**2,172**
Residential Country	215	22	19	156	5	140			4	**561**
Industrial Park, Airport Compatibility	7	2		141		285			22	**456**
Public Lands, Airport Compatibility						242			6	**248**
Planned Development	92	6	21	9	19	19		57	1	**226**
Agricultural Watershed, Urban Reserve				86						**86**
Residential	28		39	1	1	2				**72**
General Industrial, Airport Compatibility	1			42		9				**53**
Residential, Urban Reserve	16			5		5		13		**39**
Residential Country, Urban Reserve	2					35				**37**
Industrial	24				4				5	**33**
Local Commercial	10	3		2		18				**32**
Agricultural Watershed, Affordable Housing	16			14					2	**32**
Residential, Airport Compatibility				2		4		9	12	**26**
Commercial Neighborhood	16			4		4				**23**
Planned Development, Affordable Housing, Airport Compatibility			17			5				**21**
Residential Country, Affordable Housing						18				**18**
Planned Development, Airport Compatibility			12							**12**
Airport	3		3	3						**8**
Industrial, Airport Compatibility				1					3	**4**
Agricultural Watershed, Produce Stand				3						**3**
Local Commercial, other						2				**2**
Agricultural Preserve, Historic Restaurant						1				**1**
Local Commercial, Affordable Housing				1						**1**
Marine Commercial, Affordable Housing										**0**
Planned Development, Affordable Housing										**0**
Agricultural Watershed, Skyline Wilderness Park										**0**
Marine Commercial										**0**
Marine Commercial, Airport Compatibility										**0**
Total Acres	**33,794**	**3,372**	**6,574**	**21,598**	**9,709**	**9,179**	**317**	**549**	**416**	**85,503**

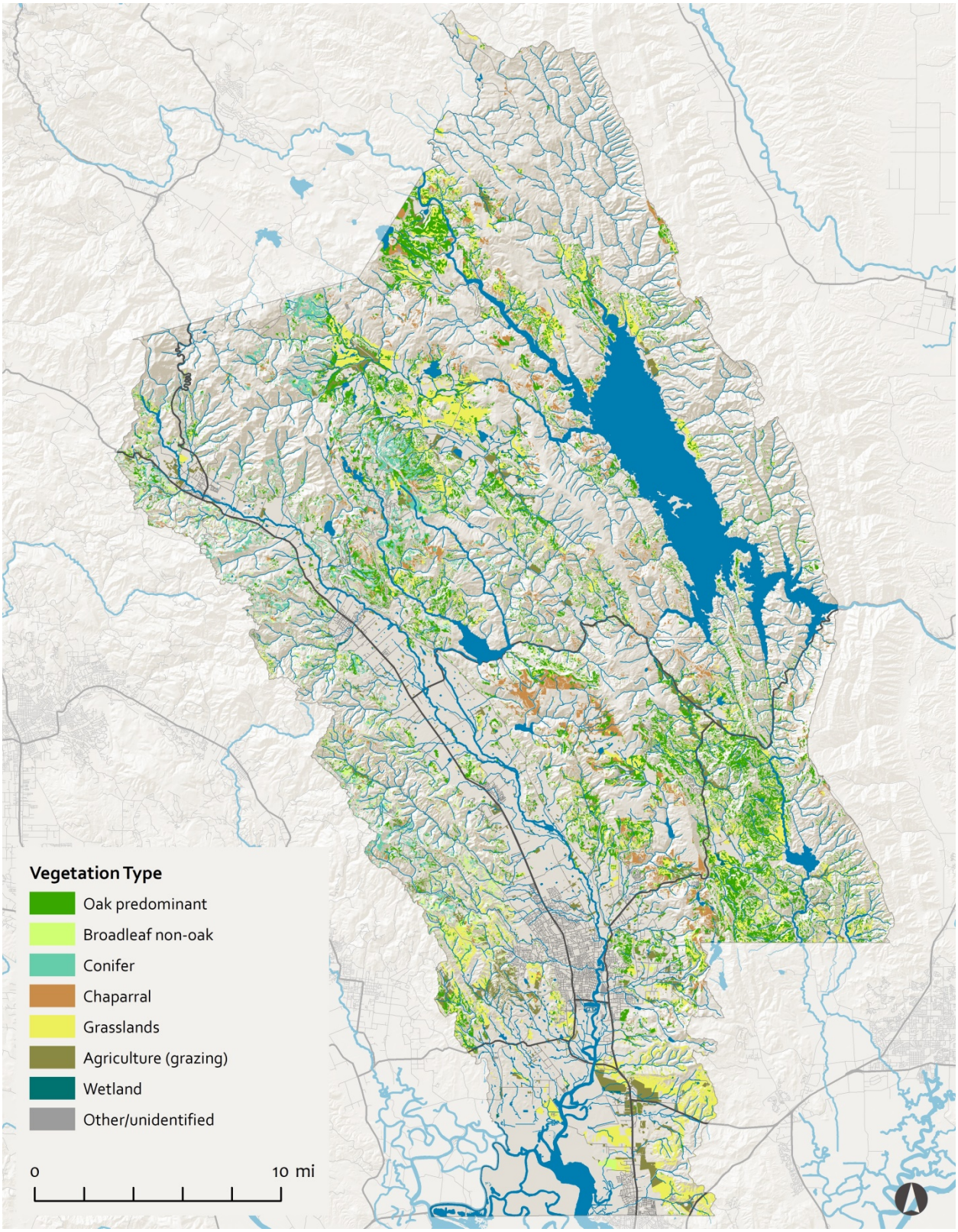


Figure 2. Napa County land at risk of development with vegetation type.
Data: Thorne 2004, County of Napa 2019, USGS 2013; 2016.

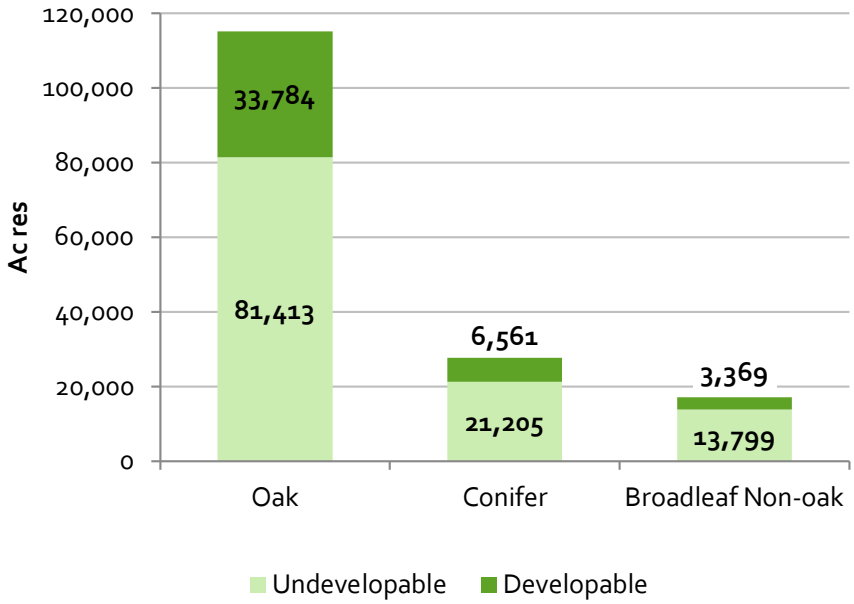


Figure 3. Developable land base model: Canopy.
Undevelopable and developable canopy, by canopy type (Data: Thorne 2004, Manfree 2018).

Table 6. Developable land base model: Canopy.
Acreage of subsets of land cover type relevant to this analysis (Data: Thorne 2004, Manfree 2018, County of Napa 2019).

	Parcels with developable land	Oak	Broadleaf non-oak	Conifer	total canopy
Developable	85,455	33,784	3,369	6,561	43,714
Undevelopable	271,834	81,413	13,799	21,205	116,417
Total	357,289	115,197	17,167	27,767	160,132

Modeling Existing 2:1 and 60/40 Policy

In addition to slope-related restrictions on development, Napa County enforces policy requiring canopy and shrubland protections. With CEQA protections adopted in 2004, oak trees are mitigated at a 2:1 ratio (State of California 1970, 2004), preferably setting aside existing trees on-site, though planting of new trees onsite or off-site are options. In the early 1990s, Napa County adopted a rule requiring retention of 60 percent of trees and 40 percent of shrubland in water supply watersheds.

These constraints can be applied to the base model to derive a more accurate estimate of existing conditions. Here the base model is described, followed by 2:1 Mitigation and 60/40 rule adjustments. Napa County has also adopted a Voluntary Oak Woodland Management Plan; participation is at landowner discretion (Napa 2010).

Allowing oak canopy mitigation on lands which are otherwise undevelopable allows about 88 percent of oak "conservation" to occur on lands which are not at risk of development, and includes an option to mitigate off-site.

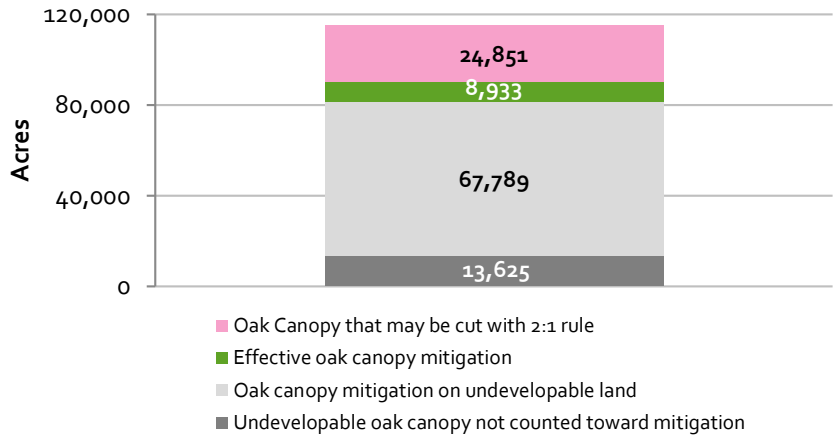


Figure 4. Effectiveness of existing 2:1 oak mitigation.
Analysis assumes landowners mitigate on-site and maximize their opportunity to count canopy or shrub on undevelopable lands toward conservation goals.

Table 7. Existing 2:1 ratio oak mitigation.

Parameter	Acres
Total Oak Canopy	115,197
Developable Oak Canopy	33,784
Undevelopable Oak Canopy	81,413
Oak Canopy Acres Set Aside by 2:1	76,722
Effective Oak Canopy Mitigation by 2:1	8,933
Oak Canopy Cut with 2:1	24,851
Total Canopy Cut with 2:1	34,782

Existing 60/40 Rule Constraints

Napa County's 60/40 rule requires retention of 60 percent of trees and 40 percent of shrubland within a parcel, as it existed June, 1993, when wildlands are converted to other uses in sensitive domestic water supply drainages ("water supply watersheds"). County guidelines state that vegetation selected for retention should maximize habitat value and connectivity. The 60/40 rule is applied in the event that it is more restrictive than 2:1 mitigation and Hillside Ordinance requirements would be. As with the 2:1 rule, the 60/40 rule allows undevelopable areas to count toward mitigation.

Remaining developable areas in agricultural watersheds tend to be dominated by oak and shrubland, followed by grassland and conifer land cover types (table 8 and figure 5).

Table 8. Developable area in sensitive domestic water supply drainages, by vegetation type.
See Appendix 2 for description of categories (Data: Thorne 2004, USGS 2017, County of Napa 2019).*

	Vegetation Type							
Watershed	Oak predominant	Broadleaf non-oak	Conifer	Chaparral	Grasslands	Agriculture (grazing)	Other	Total Acres
Hennessey	2,821	227	1,090	1,077	910	516	41	**6,682**
Curry	2,050	0	2	107	618	6	16	**2,799**
Rector	335	23	9	1,238	90	110	28	**1,833**
Milliken	623	101	7	421	280	85	67	**1,583**
Bell Canyon	163	16	111	158	17	31	10	**506**
Madigan	145	14	0	133	20	48	0	**360**
Kimball	84	2	58	8	67	0	0	**219**
Total Acres	**6,221**	**382**	**1,276**	**3,143**	**2,001**	**796**	**162**	**13,982**

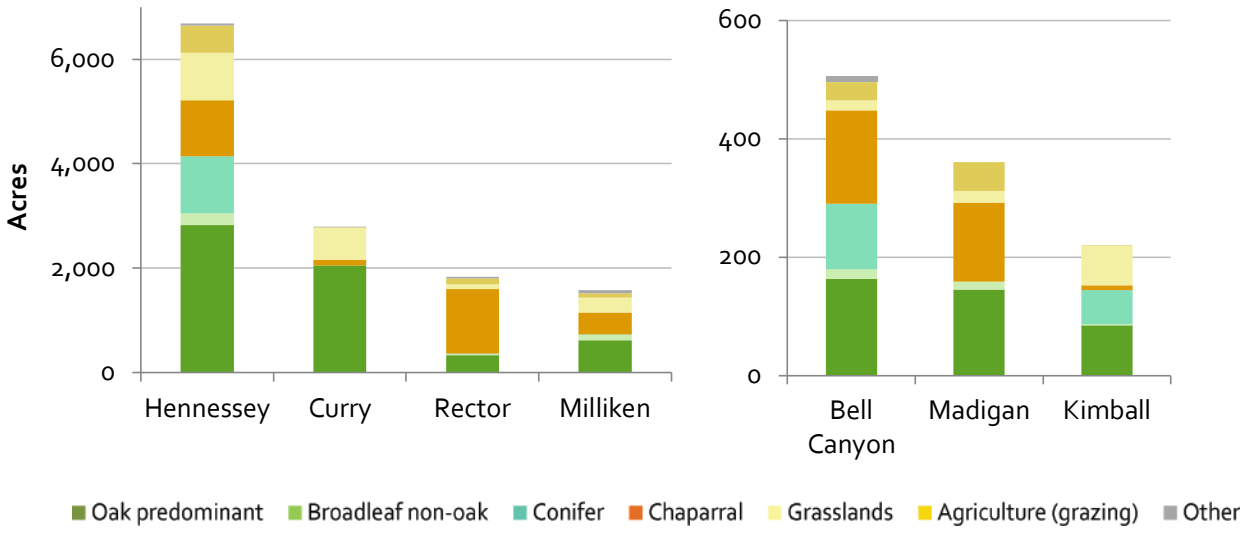


Figure 5. Developable vegetation types in sensitive domestic water supply drainages.
See Appendix 2 for description of categories (Data: Thorne 2004, USGS 2017, County of Napa 2019). Analyses assume landowners maximize their opportunity to count canopy or shrub on undevelopable lands toward conservation goals. Note difference in scales.

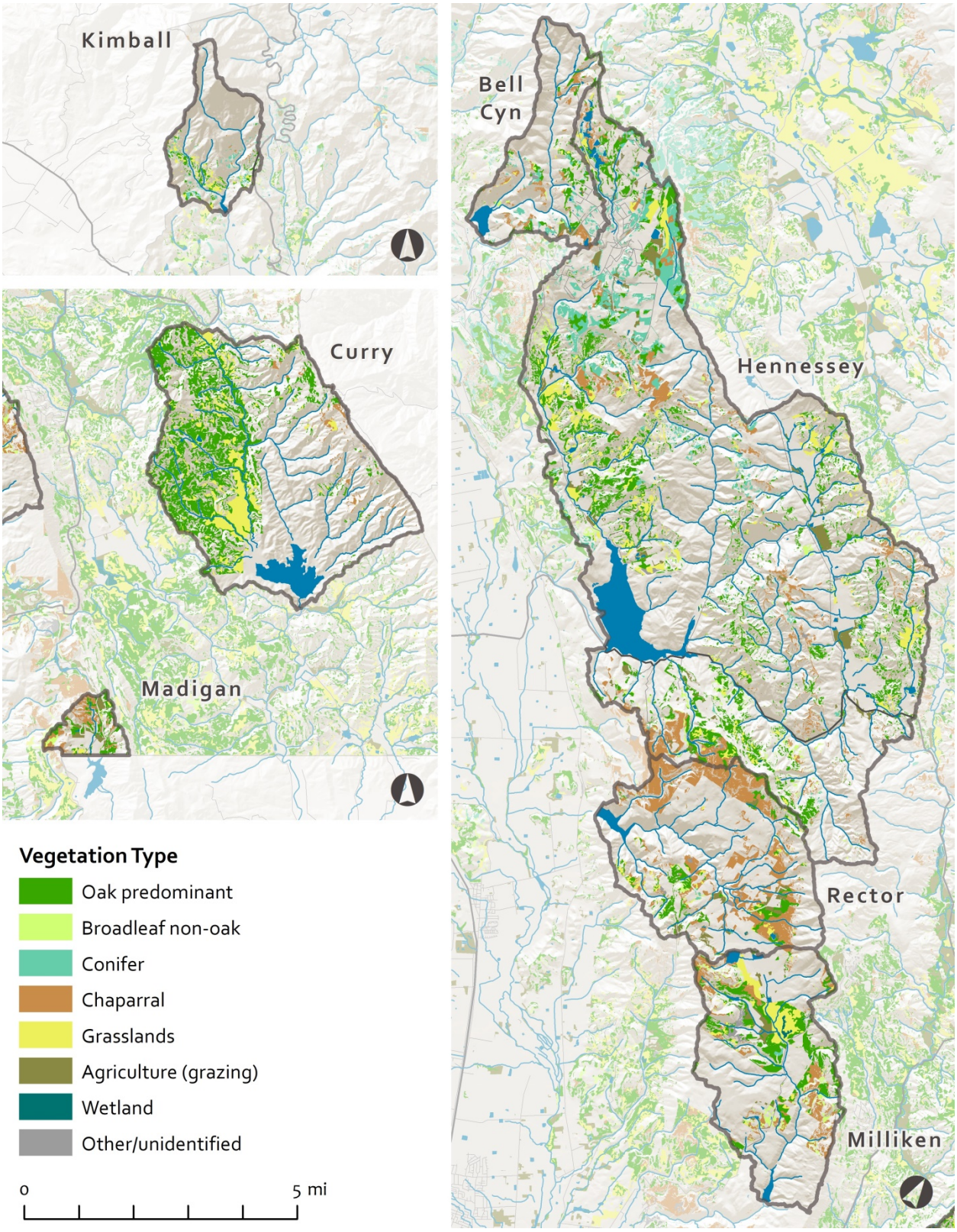


Figure 6. Developable land in sensitive domestic water supply drainages with vegetation type.
Data: Thorne 2004, County of Napa 2019, USGS 2013; 2016.

Due to the large amount of area precluded from development by slope and stream setbacks that are designed to protect drinking water supplies, almost all 60/40 "retention" occurs on lands that are not at risk of development. Applying 60/40 conservation requirements to parcels which currently have developable land shows that, if developed, 91% (13,879 acres) of canopy "retention," and 93% (3,703 acres) of shrub "retention," may occur on undevelopable areas within these parcels. The existing 60/40 rule effectively protects only about 1,660 acres, or 5 percent, of the 31,034 total acres in water supply drainages (figure 7).

The goal of the 60/40 rule was to protect water supplies; however it is unlikely that a 5 percent increase in protected area over the slope and stream setback requirements is accomplishing the objective it was designed to meet. Allowing conservation credit for retention of shrub and canopy in undevelopable areas seriously undermines the effectiveness of the rule.

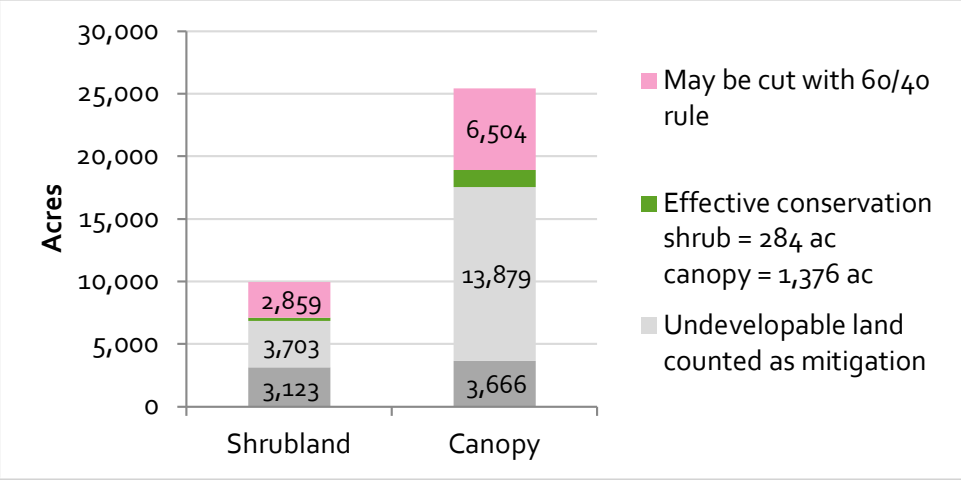


Figure 7. 60/40 Retention Rule Effects
Outcomes of the existing 60/40 policy. (Data: Thorne 2004, USGS 2017, County of Napa 2019). Analyses assume landowners maximize their opportunity to count canopy or shrub on undevelopable lands toward conservation goals.

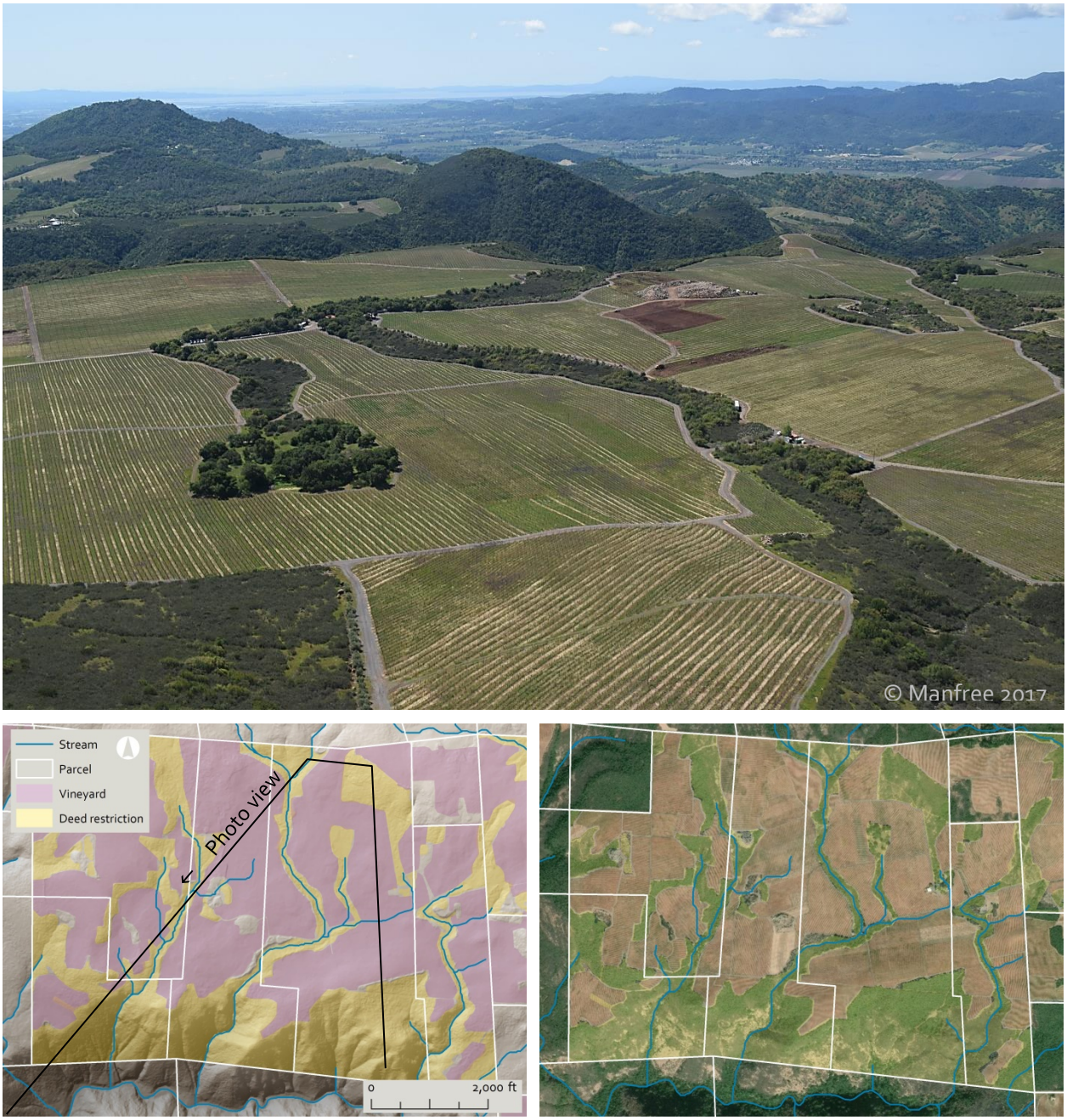


Figure 8. Application of 60/40 policy in Rector Watershed. Original land cover was predominantly shrubland. In the application of the policy, six contiguous parcels with one owner were treated as one, and 472 acres of 1,131 total acres were set aside (42%). Conservation goals are met almost entirely within stream setbacks and on steep slopes and remaining lands have been developed. Oblique aerial photo looking southwest (a), topographic map view (b), aerial photo map view (c).

Conservation Easements and Deed Restrictions

The 60/40 rule went into effect in 1993. Wildland conversion projects have occurred on about 130 parcels in sensitive water supply drainages since then. There are five projects with deed restrictions or conservation easements, involving 16 parcels, recorded as of 2018 (Napa County Assessor; Planning Staff). Areas of canopy and shrub set aside by the CEQA 2:1 requirement and Hillside Ordinance slope

and stream setbacks often meet or exceed 60/40 required conservation goals, so no additional acreage is set aside.

Sixty-forty rule outcomes were researched by identifying parcel numbers for all vineyards built since 1993 and reviewing deeds at the Napa County Assessor's office. The research process underscored the difficulty in tracking this policy. As land ownership changes through time, maintaining conservation targets through deed restrictions may present difficulties. Deed restrictions are not explicitly conservation-oriented and may require active advocacy to avoid nullification over time. The mechanism for codifying conservation associated with local policies is beyond the scope of this report, but should be evaluated and discussed.

Table 9. Deed restrictions and conservation easements associated with Napa County wildland-agricultural conversion projects.

Project (parcel count)	Document Number	Erosion Control Plan	Total Acres	Vineyard Acres	Reserve Acres	Reserve Percent	Type
Cordoniu Napa (1)	2009-0020950	1226	181	95	77	43%	Deed restriction
Stagecoach (6)	2009-0007662	P06-00420	1,131	625	472	42%	Deed restriction
Rodgers (7)	2014-0010438	P14-00309	679	148	462	68%	Conservation easement
Circle S Forever Wild (1)	2017-0013728	P06-01508	314	(unbuilt)	122	39%	Conservation easement
Ciminelli (1)	2018-0001247	P15-00006	41	(unbuilt)	15	37%	Deed restriction

Discussion of 2:1 Mitigation Ratio and 60/40 Retention Rule

Whether 2:1 ratio of canopy mitigation or the 60/40 rule protects more area on a given parcel depends on land cover. Two-to-one (66%) oak mitigation, if required on-site and with retention of existing trees, is more stringent in parcels with abundant oak canopy than a 60% canopy retention rule. In water supply watersheds areas with chaparral and conifer, the 60/40 rule will tend to conserve more area. However, given the option to mitigate on steep slopes and in stream setbacks, the "effective conservation" of both policies is restricted. "Effective conservation" discussed here refers to additional conservation acreage beyond that required by slope and stream setbacks.

- If all developable oak forests were converted under the CEQA2:1 Mitigation rule, with landowners maximizing mitigation in undevelopable areas, up to 24,800 acres of oaks could potentially be converted to other uses, while 8,933 acres of oaks would be prevented from development by the rule.

- If all developable forest and shrubland in water supply watersheds were converted under the 60/40 rule, with landowners maximizing mitigation in undevelopable areas, up to 9,360 acres of trees and shrubs could potentially be converted to other uses, while 1,660 acres would be prevented from development by the rule.

In sum, the 2:1 Mitigation rule and the 60/40 rule preclude 9,588 acres of wildlands from conversion to agriculture or other uses. This reduces county-wide developable area from 85,500 (base model) to about 75,900 developable acres. These are existing conditions. As the 60/40 rule has a very minor conservation impact, it is not considered further in this analysis.

Box 1. Effect of allowing mitigation on undevelopable land

Counting undevelopable lands toward mitigation allows 80% to 90% of the total acreage set aside by a policy (county-wide) to be mitigated on lands that are not available for development.

Percentages of mitigation/retention which may occur on undevelopable land, per policy:

60/40 canopy/shrub retention - existing policy
91% of canopy retention
93% of shrubland retention

2:1 oak canopy mitigation - existing policy
88% of oak mitigation

3:1 canopy mitigation - proposed
87% of canopy mitigation

85% canopy retention - proposed
82% of canopy retention

Comparing Policy Outcomes

Whether or not mitigation is allowed on undevelopable lands is the single biggest determinant of how much land is protected from development, for options under discussion. Below, current policy protections are compared with alternative options. The California 2:1 oak mitigation policy sets a limit on the cutting of oaks and, if local policy were expanded to protect all trees, the 2:1 state policy would set a floor on oak deforestation. Beyond that, the outcomes for specific types of trees would be unpredictable, unless codified (table 10).

Table 10. Mitigation or retention options sorted by amount of canopy area protected.
*Assumes undevelopable areas count toward mitigation. ^Assumes undevelopable areas do not count toward mitigation. Areas expressed in acres.

Policy	Canopy set aside by rule(s)	Canopy precluded from cutting	Total Canopy Protected	Canopy at Risk	Increase in Canopy Protection
Current policy:					
2:1 oak and 60/40*	76,722	9,304	125,721	34,411	n/a
3:1 Mitigation*	120,099	15,855	132,273	27,859	4%
2:1 mitigation^	29,143	29,143	145,560	14,571	12%
3:1 Mitigation^	32,786	32,786	149,203	10,929	14%
85% Retention^	37,157	37,157	153,574	6,557	17%

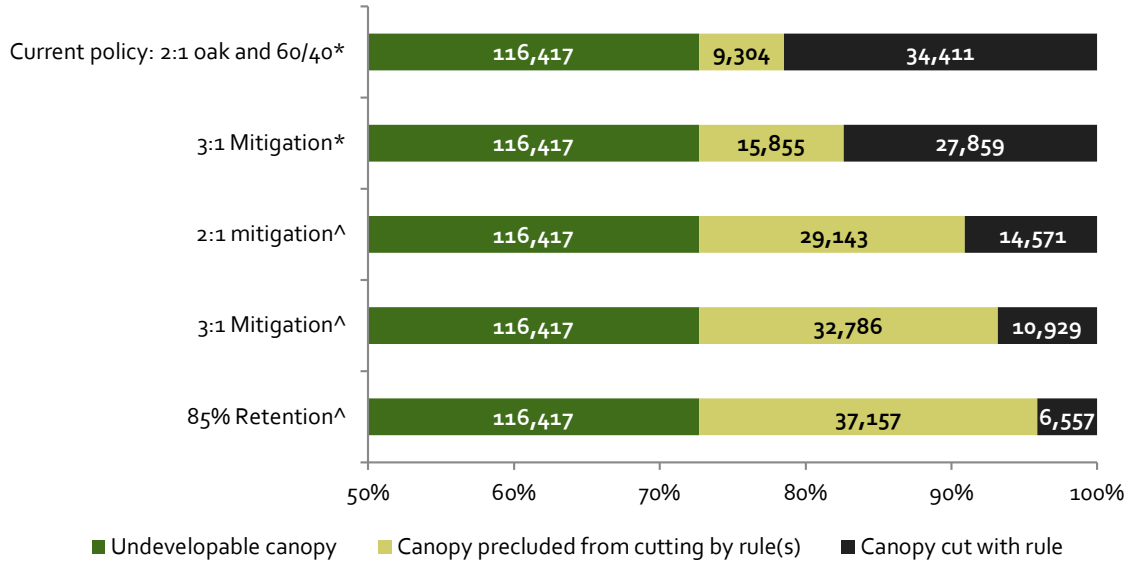


Figure 9. Mitigation or retention option ranked by canopy area protected.
*Assumes undevelopable areas count toward mitigation. ^Assumes undevelopable areas do not count toward mitigation. Areas expressed in acres.

Table 11. Complete Assessment of Policy Outcomes.

On-site mitigation is assumed for all scenarios. All inputs are listed in table 6.
*Assumes undevelopable areas count toward mitigation
^ Assumes undevelopable areas can't count toward mitigation

Policy Variable	Parameter	Acres	Operation
2:1 (66%) Oak Mitigation*	Oak Canopy Acres Set aside by 2:1*	76,722	Total oak * 0.66
	Oak Canopy Precluded from Cutting by 2:1*	8,933	Max of zero or (oak set aside - undevelopable oak)
	Oak Canopy Cut with 2:1*	24,851	Developable oak - oak precluded from cutting
	Total Canopy Cut with 2:1*	34,782	Oak cut + developable conifer + developable non-oak
2:1 (66%) Canopy Mitigation*	Canopy Acres Set Aside by 2:1*	105,687	Parcel total canopy * 0.66
	Canopy Precluded from Cutting by 2:1*	10,090	Max of zero or (canopy set aside - undevelopable canopy)
	Canopy Cut with 2:1*	33,624	Developable canopy - canopy precluded from cutting
	Total Canopy Protected with 2:1*	126,507	Undevelopable canopy + canopy precluded from cutting
2:1 (66%) Canopy Mitigation^	Canopy Acres Set Aside by 2:1^	28,851	Developable canopy * 0.66
	Canopy Cut with 2:1^	14,426	Developable canopy * 0.33
	Total Canopy Protected with 2:1^	145,706	Total canopy - canopy cut
70% Canopy Retention*	Canopy Set Aside by 70%*	112,092	Parcel total canopy * 0.70
	Canopy Precluded from Cutting by 70%*	12,448	Max of zero or (canopy set aside - undevelopable canopy)
	Canopy Cut with 70%*	31,267	Developable canopy - canopy precluded from cutting
	Total Canopy Protected with 70%*	128,865	Undevelopable + canopy precluded from cutting
70% Canopy Retention^	Canopy Set Aside by 70%^	30,600	Developable canopy * 0.70
	Canopy Cut with 70%^	13,114	Developable canopy * 0.30
	Total Canopy Protected with 70%^	147,017	Total canopy - canopy cut
3:1 (75%) Tree Mitigation*	Canopy Set Aside by 3:1*	120,099	Total canopy * 0.75
	Canopy Precluded from Cutting by 3:1*	15,855	Max of zero or (canopy set aside - undevelopable canopy)
	Canopy Cut with 3:1*	27,859	Developable canopy - canopy precluded from cutting
	Total Canopy Protected with 3:1*	132,273	Undevelopable canopy + canopy precluded from cutting
3:1 (75%) Canopy Mitigation^	Canopy Set Aside by 3:1^	32,786	Developable canopy * 0.75
	Canopy Cut with 3:1^	10,929	Developable canopy * 0.25
	Total Canopy Protected with 3:1^	149,203	Undevelopable canopy + canopy precluded from cutting
85% Canopy Retention*	Canopy Set Aside by 85%*	136,112	Parcel total canopy * 0.85
	Canopy Precluded from Cutting by 85%*	24,509	Max of zero or (canopy set aside - undevelopable canopy)
	Canopy Cut with 85%*	19,206	Developable canopy - canopy precluded from cutting
	Total Canopy Protected with 85%*	140,926	Undevelopable + canopy precluded from cutting
85% Canopy Retention^	Canopy Set Aside by 85%^	37,157	Developable canopy * 0.85
	Canopy Cut with 85%^	6,557	Developable canopy * 0.15
	Total Canopy Protected with 85%^	153,574	Total canopy - canopy cut

Reservoir Setbacks

Lands adjacent to most Napa County reservoirs are held by government agencies and/or have reserve status, and are therefore not available for development. Due to these conditions, large setbacks are required to substantively reduce developable area near reservoirs. Most developable areas within 200, 500, and 1,000 foot reservoir setbacks are of CDC "other land" quality. Erosion from upland agriculture into water supply reservoirs causes the public to bear the expense of maintenance needed due to upstream uses benefitting private companies. Even with existing dedicated policy, fine sediment delivery is a problem (Wooster pers. comm.), so additional protections should be considered.

Sediment transport of flowing water is not determined solely by distance. The mechanical power (work per time) being dissipated in a river or stream at high flows, in combination with sediment sources, determine sediment transport. Steep drainages can transport surprisingly high amounts of sediment long distances during peak flows.

Previous cases anecdotally suggest that setbacks of 500 feet would not be adequate to protect sensitive domestic water supply drainages. The Viader hillside vineyard, which caused a 1990 landslide into Bell Canyon Reservoir, was over 500 feet from the reservoir edge, and the majority of vineyards likely causing turbidity at Friesen Lakes are more than 500 feet from reservoir edges.

Table 12. Development precluded by 200 foot reservoir setback.

Reservoir	Higher-quality farmland	Grazing land	Other land	Total acres
Bell Canyon				**0**
Berryessa	1	33	29	**68**
Curry				**0**
Friesen			54	**54**
Hennessey	0	1		**1**
Kimball			2	**2**
Madigan		1		**1**
Milliken				**0**
Rector				**0**
Total acres	**1**	**35**	**85**	**126**

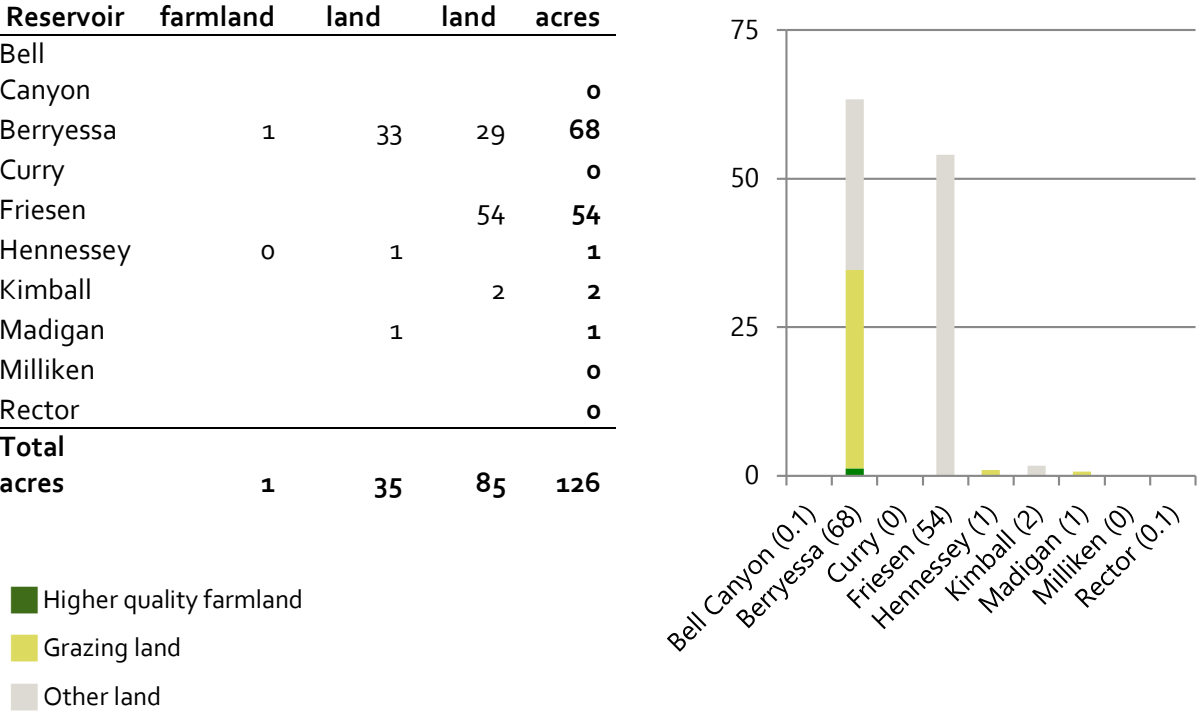


Table 13. Development precluded by 500 foot reservoir setback.

Reservoir	Higher-quality farmland	Grazing land	Other land	Total acres
Bell Canyon			2	**2**
Berryessa	16	148	83	**248**
Curry				**0**
Friesen			111	**111**
Hennessey	2	8		**11**
Kimball			10	**10**
Madigan		7		**7**
Milliken				**0**
Rector				**0**
Total acres:	**18**	**164**	**206**	**389**

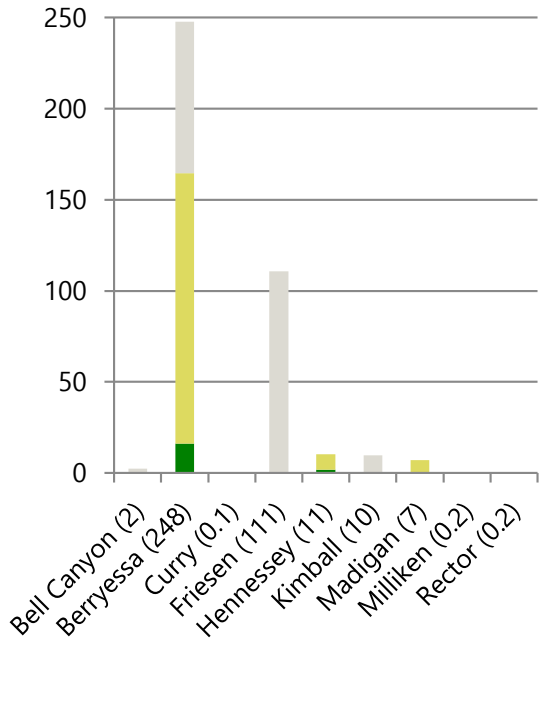
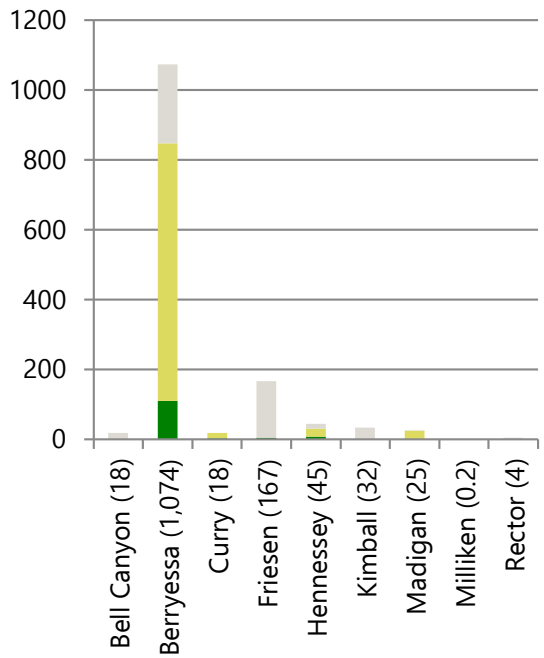


Table 14. Development precluded by 1,000 foot reservoir setback.

Reservoir	Higher-quality farmland	Grazing land	Other land	Total Acres
Bell Canyon			18	**18**
Berryessa	109	739	226	**1,074**
Curry	3	15		**18**
Friesen	4		163	**167**
Hennessey	7	23	15	**45**
Kimball			32	**32**
Madigan		24	1	**25**
Milliken				**0**
Rector			4	**4**
Total acres:	**123**	**801**	**459**	**1,382**



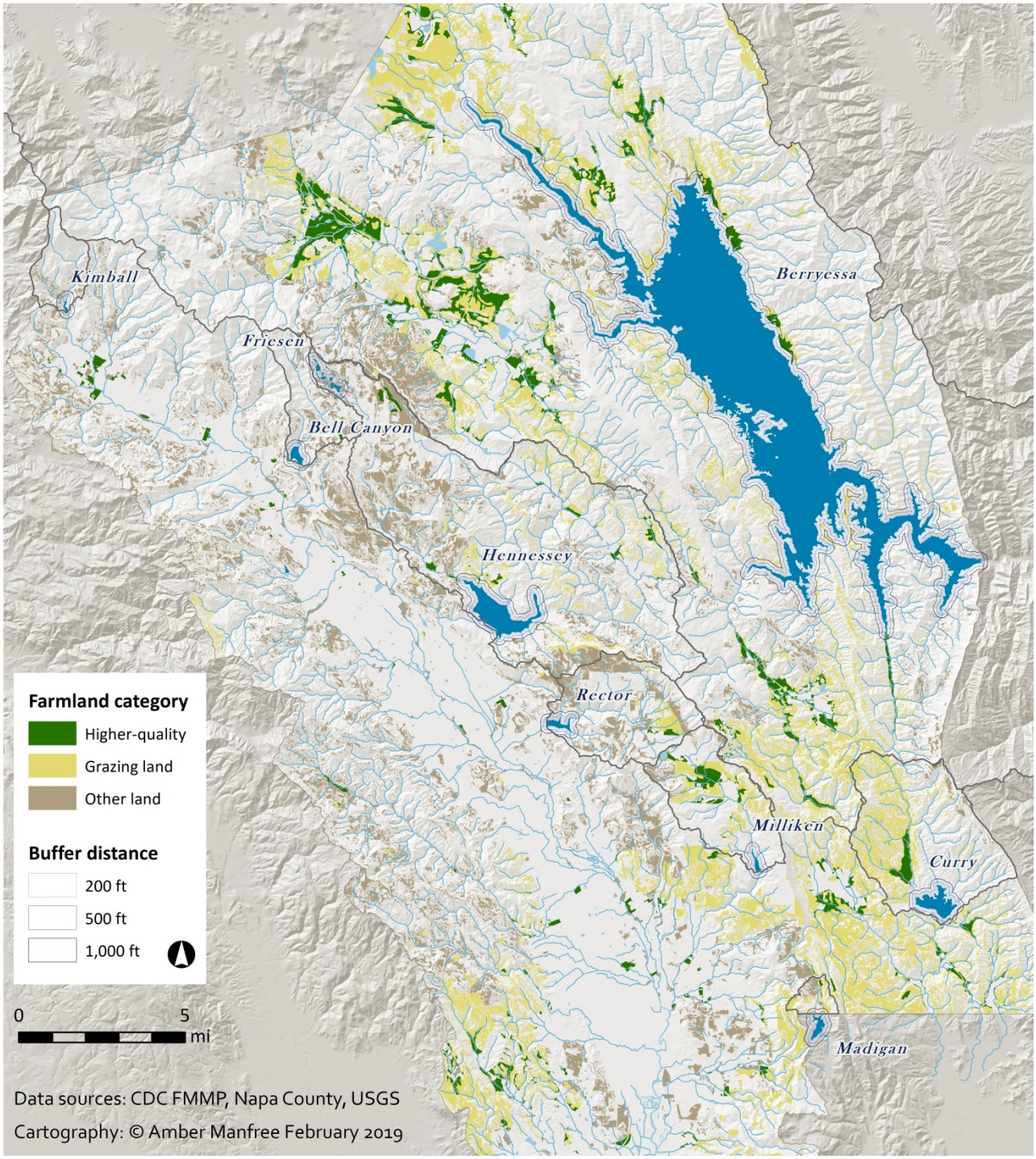


Figure 10. Municipal and drinking water supply reservoir setbacks and farmland quality of developable lands.

Wetland Setbacks

To model the potential impacts of increased wetland protections, a 150 foot buffer was applied to a subset of the US Fish and Wildlife Service wetland dataset (USFWS 2016) "Pond" category and portions of the "Freshwater Emergent Wetland" category that are not adjacent to streams in the model. This buffered subset was intersected with the base model for developable area and with CDC farmland data.

Wetland buffers of 150 feet would preclude 3,304 acres from development.

Wetlands included in this analysis are 5% of Napa County's total area. Applying 150 foot setbacks to these wetlands precludes 3,304 acres, or 4% of developable area from development. Wetlands are generally located in low-lying areas with alluvial soils, which are also typically of higher agricultural value.

Overlap between canopy and wetland is not addressed by this analysis.

Table 15. Countywide USFWS wetlands included in analysis.

Wetland type	Acres
Freshwater emergent	2,097
Freshwater pond	1,854
Lake	24,470*
Total wetland	28,421

*Includes Lake Berryessa

Developable Area and Parcel Size

There are about 49,768 parcels in Napa County. Of these, there are about 8,800 parcels with more than 1,000 square feet of developable area.

Table 16. Parcel distribution by size and Land Use Zone; for parcels with > 1,000 ft² developable area.

	Parcel Size			
Land Use Zone	< 1 acre	1 to 5 acre	> 5 acre	**Total Parcels**
Agricultural Watershed	305	1,088	3,752	**5,145**
Municipal/ urban	628	332	258	**1,218**
Agricultural Preserve	40	242	669	**951**
Residential Country	47	164	151	**362**
Residential	221	62	27	**310**
Planned Development	235	41	30	**306**
Agricultural Watershed, Airport Compatibility	26	40	133	**199**
Industrial Park, Airport Compatibility	17	42	49	**108**
Residential, Urban Reserve	51	24	10	**85**
Local Commercial	3	5	18	**26**
Commercial Neighborhood		5	10	**15**
Residential, Airport Compatibility	5	2	8	**15**
Residential Country, Urban Reserve		5	7	**12**
Industrial	1	1	8	**10**
Airport		4	5	**9**
Industrial, Airport Compatibility		1	6	**7**
Agricultural Watershed, Skyline Wilderness Park		2	3	**5**
Agricultural Watershed, Affordable Housing			5	**5**
General Industrial, Airport Compatibility		1	3	**4**
Agricultural Preserve, Historic Restaurant	2	1	1	**4**
Agricultural Watershed, Urban Reserve		1	2	**3**
Planned Development, Affordable Housing, AC	1	1	1	**3**
Marine Commercial		1	1	**2**
Marine Commercial, Affordable Housing			2	**2**
Public Lands, Airport Compatibility			2	**2**
Local Commercial, Affordable Housing	1		1	**2**
Planned Development, Airport Compatibility	1			**1**
Marine Commercial, Airport Compatibility			1	**1**
Residential Country, Affordable Housing			1	**1**
Agricultural Watershed, Produce Stand		1		**1**
Total Parcels:	**1,584**	**2,066**	**5,164**	**8,814**

Small Parcels Quick Reference

County-wide total number of 0 to 5 acre parcels	42,702 parcels

Parcels less than 1 acre

Countywide total	38,071 parcels
With more than 1,000 square feet developable area	1,584 parcels

Homes: essentially all buildable parcels (not roads or slivers) less than one acre have homes

1 to 5 acre

Countywide total	4,631 parcels
With more than 1,000 square feet of developable area	2,066 parcels

Homes: about 1,790 one-to-five acre parcels with >1,000 ft^2 developable area, or 86%, have homes

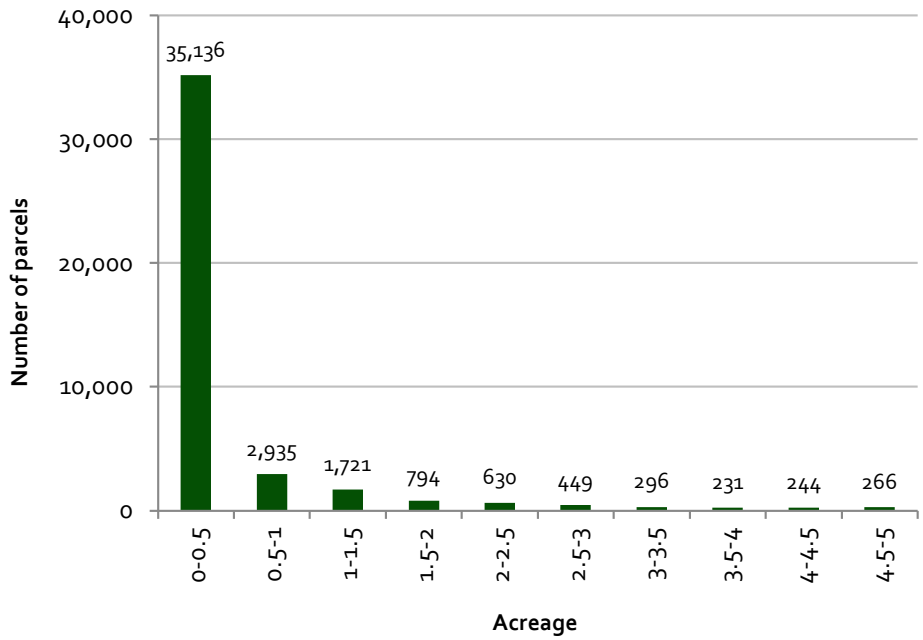


Figure 11. Distribution of zero to five-acre parcels, classified by size.

Remarks

Reviewing aerial photos suggests that developable areas within the majority of <1 acre parcels are unlikely to be converted to agriculture as they are being used as yards.

Home-related figures were estimated using Napa County's "ADDRESSES" dataset, which includes street addresses for houses, as well as addresses not assigned to houses. This likely resulted in a minor overestimate of total homes.

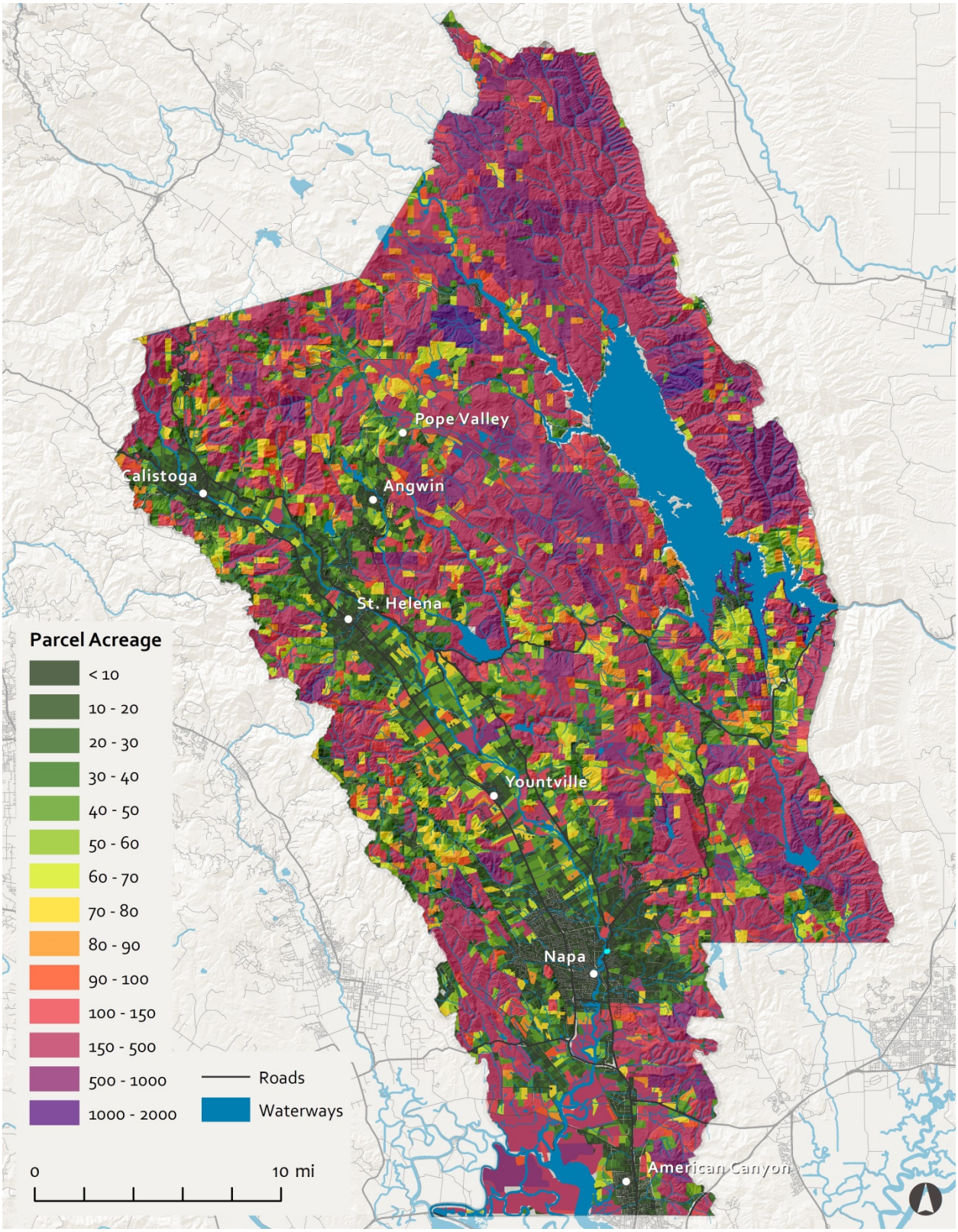


Figure 12. Napa County parcel size.
Small parcels are clustered in towns, valleys, and along roads; large parcels are common on ridgetops and in remote areas (Data: County of Napa 2019).

Developable Area Farmland Quality and Land Cover

The quality of farmland influences how desirable an area is for development. These tables summarize land cover, categorized by Thorne (2004) and Farmland Type, as categorized by the California Department of Conservation (2016) in areas which are developable under current policy.

As the land cover/type categories were developed individually, with different purposes and at different times, there is some agreement and some disagreement about convergent categories, such as grazing.

Table 17. Developable Area Farmland Quality and Land Cover.
Data: (Thorne 2004, CDC 2016, Manfree 2019)

	Farmland Type - Higher Quality Farmland								
Land Cover Category	**Local importance**	**Statewide importance**	**Prime**	**Unique**	**Grazing**	**Other**	**Urban**	**Water**	**Total Acres**
Oak predominant	1,177	9	42	96	21,555	10,442	441	22	33,784
Grasslands	5,354	28	26	56	13,083	2,875	151	20	21,591
Chaparral	76	1	0	10	3,584	6,014	11	4	9,701
Agriculture (grazing)	3,230	450	505	216	1,943	2,435	390	1	9,169
Conifer	8	3	3	25	553	5,842	128	0	6,561
Broadleaf non-oak	30	10	3	15	971	2,306	35	0	3,369
Vacant	19	0	1	5	78	382	63		548
Wetland	144	0	5	1	153	98	12	1	415
Unidentified	31	1	0	0	153	131	1		317
Urban						0	0		0
Total Acres:	**10,067**	**502**	**586**	**423**	**42,073**	**30,526**	**1,231**	**48**	**85,455**

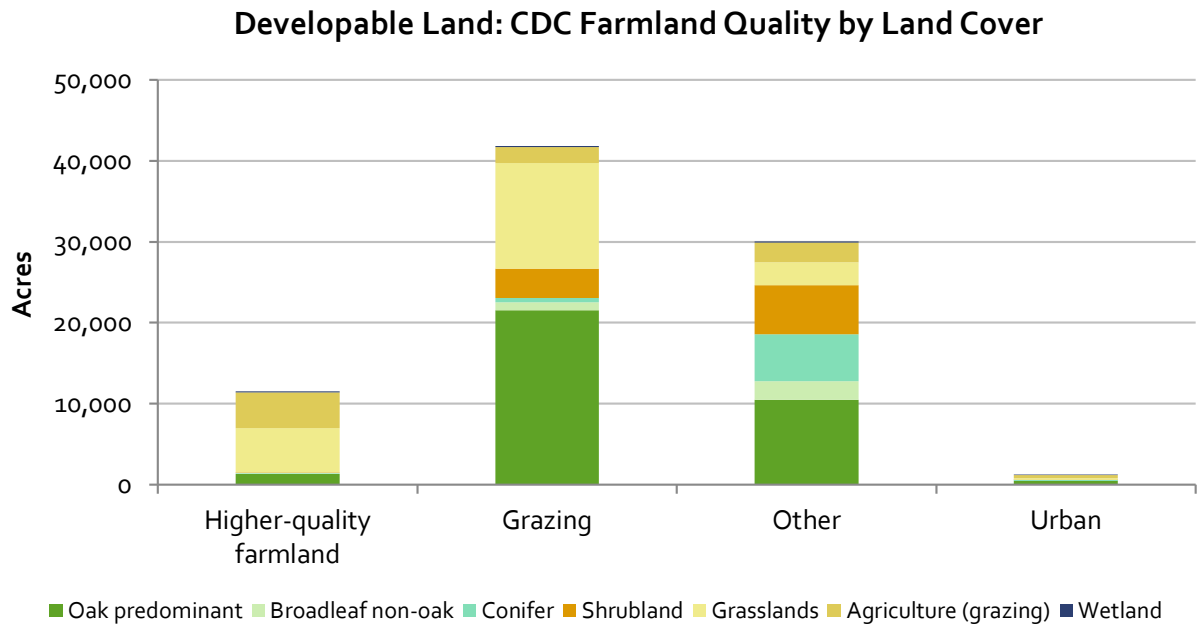


Table 18 (part 1 of 2). Developable area, Farmland Quality and Land Cover by Land Use Zone.
(Data: Thorne 2004, CDC 2016, Manfree 2019) Continued on next page.

	Farmland Type - Higher Quality Farmland								
Land Cover Category	Local importance	Statewide importance	Prime	Unique	Grazing	Other	Urban	Water	Total Acres
Agricultural Watershed (AW)									
Agriculture (grazing)	2,123	65	129	179	1,693	1,774	54	1	**6,016**
Broadleaf non-oak	22	2	2	13	945	2,024	13	0	**3,022**
Chaparral	76	1	0	10	3,573	5,837	4	4	**9,506**
Conifer	5	2	0	24	545	5,006	65	0	**5,647**
Grasslands	4,291	6	12	46	11,329	2,364	57	20	**18,125**
Oak predominant	1,073	8	19	71	21,147	9,070	175	22	**31,584**
Unidentified	28	1		0	135	118			**281**
Urban						0	0		**0**
Vacant	6	0	1	5	73	228	1		**314**
Wetland	98	0	5	1	130	53		1	**287**
AW, Airport Compatibility (AC)									
Agriculture (grazing)	200	236	103	14	93	97	85		**828**
Broadleaf non-oak	1	2	0	0	11	30	0		**45**
Chaparral				0	7	156			**163**
Conifer	1	1	0	1	1	643	5		**652**
Grasslands	261	19	5	7	1,423	25	4		**1,744**
Oak predominant	7	0	0	2	103	449	8		**570**
Unidentified	3	0			18				**21**
Wetland	1	0		0	10	0	0		**11**
Agricultural Preserve									
Agriculture (grazing)	232	20	145	22	53	410	69		**952**
Broadleaf non-oak	3	1	0	1	3	59	0		**68**
Chaparral						0			**0**
Conifer	0		0	0	0	85	0		**86**
Grasslands	156	2	8	2	165	132	4		**469**
Oak predominant	82	1	20	23	113	605	12		**857**
Unidentified			0	0		9			**9**
Vacant			0	0		13	1		**14**
Wetland	16	0	0		3	4	0		**24**

Table 18 (part 2 of 2). Developable area, Farmland Quality, and Land Cover by Land Use Zone.
Continued from previous page.

Municipal/ urban									
Agriculture (grazing)	262	7	18	1	99	83	115		**585**
Broadleaf non-oak	2	5	0		11	172	11		**201**
Chaparral						2			**2**
Conifer	0	0	0	0	1	60	4		**65**
Grasslands	497		0	1	116	119	51	0	**784**
Oak predominant	1		1	1	14	195	133		**344**
Unidentified				0		5	1		**6**
Vacant	12		1	0		91	37		**141**
Wetland	2		0	0	1	30	5		**38**
Residential Country									
Agriculture (grazing)	53	0	10	0	1	46	29		**139**
Broadleaf non-oak	1			0	0	17	5		**22**
Chaparral					1	5			**5**
Conifer			0	0	6	12			**19**
Grasslands			0	1	21	122	12		**156**
Oak predominant	2		2		139	42	29		**214**
Wetland						1	3		**4**
Industrial Park, AC									
Agriculture (grazing)	260		0				24		**285**
Broadleaf non-oak	2								**2**
Grasslands	110				16	3	13		**141**
Oak predominant	7		0						**7**
Wetland	22						0		**22**
Public Lands, AC									
Agriculture (grazing)	29	122	81		3	4	3		**242**
Grasslands	0	0	0						**0**
Oak predominant			0						**0**
Wetland	1	0				5			**6**
Planned Development									
Agriculture (grazing)	0		18				1		**19**
Broadleaf non-oak					0	2	4		**6**
Chaparral	0		0		3	10	6		**19**
Conifer	0		2		0	11	8		**21**
Grasslands	0				0	9	0		**9**
Oak predominant	0		0		2	45	44	0	**91**
Vacant					5	30	22		**57**
Wetland						0	1		**1**
Other Land Use Zones	118	0	1	0	63	215	108	0	**505**
Total Acres:	**10,067**	**502**	**586**	**423**	**42,073**	**30,526**	**1,231**	**48**	**85,455**

Section 3 - Methods

There are two main components of this analysis; a base model for developable area and a mathematical model of potential policy impacts. The developable area base model is spatial, created in a geographic information system (GIS) with existing and custom inputs. It was combined with other spatial data to evaluate types of land cover available for development, and to explore potential policy impacts related to vegetation type, reservoirs, and streams.

The base model is subtractive. Beginning with the entire area of Napa County, areas unsuitable for conversion to agriculture have been removed. Examples of areas unsuitable for agriculture include lands with slopes over 30 percent (precluded from development by local ordinance), open water, reserves, existing agriculture, roads, railroads, and stream setbacks. "Developable" polygon areas under 1,000 square feet were removed from the analysis. Houses, driveways, and slivers were removed with hand-digitization, with most attention on the Agricultural Preserve Zone, where these features significantly skewed "developable" total area. See "1. Base Model: Existing Constraints to Development" table below for a complete list of areas removed.

The base model for developable land was intersected with zoning, vegetation, soil quality, and parcel datasets to assess the distribution and total area of feature types and support a parcel-scale analysis of proposed policy impacts, which was completed in spreadsheet software.

Project design is completed on an individual basis by applicants and county planning staff. Many decisions are made at that juncture, which are not possible to include in a county-scale model. For example, adjacent parcels may be managed as one contiguous area when deciding where to accomplish mitigation, which may result in more area being developed on a single parcel than would be allowed if the parcel were considered in isolation. Conversely, the adjacent parcel may have more than the required area set aside to make up the difference.

Another element that determines site-scale decisions is CEQA compliance. Assessments of habitat and other environmental impacts are made during the application process. This may lead to more area being set aside to mitigate or avoid significant impacts to the environment. Modeling effects of CEQA compliance on county-wide development is beyond the scope of this analysis.

Below are notes on source data considerations for select datasets and geoprocessing methods, followed by tables summarizing analysis steps.

Slope

Slope was generated with LiDAR digital elevation models prepared by Towill Incorporated for the County of Napa with aerial imagery acquired in 2002. Datasets for the Napa River watershed and non-Napa River watershed were created at different spatial resolution and are distributed separately. To support a county-wide analysis, the less-resolved non-Napa River watershed dataset was resampled to match the cell size resolution of the Napa River watershed dataset, the two datasets were mosaicked, and missing data were patched with Focal Statistics to provide a continuous surface. The resulting raster was used to generate a county-wide slope dataset that was sorted into classes above and below 30 percent slope, and then converted to vector format for geoprocessing.

Existing Vineyard

Napa County provides data on crop type in its "agriculture_public" shapefile. The most recent available version having was updated by County GIS staff in 2016. This data was hand-edited to reflect vineyard projects built between 2016 and early 2019 using aerial imagery provided by ESRI and Google Earth for reference.

Vegetation Types

The Vegetation dataset for Napa County produced by James Thorne in 2002-2004 for the County of Napa was used for this analysis (Thorne 2004). The dataset is currently under revision, and the update may be incorporated in future analyses. See appendix 1 for more information on this dataset.

Streams

Stream location data prepared by USGS is not extensive and not closely fitted to the LiDAR-generated digital elevation model used for slope analysis. The streams dataset is an acceptable approximation of actual streams for a county-wide analysis. A revised streams dataset would be of great benefit to Napa County, and could be produced with a watershed analysis of the LiDAR and expert digitization.

Stream Setback Buffers

Fifty-foot buffers were applied to USGS blueline stream centerlines to approximate stream setback requirements. Planning staff evaluate stream setbacks on a site-by-site basis with setbacks ranging from 35 to 150 feet from bankfull depending on slope of adjacent land (Napa 2006). Theoretically, as streams get wider, adjacent slopes are lower. As permits are generally not granted to develop areas with over 30% slope, a 50-foot setback is a reasonable model choice, as it accounts for bankfull width of the stream itself plus a setback in the median range for projects on slopes less than 30 percent. Modeling site-specific stream setbacks related to slope could be accomplished with a hydrological model, but is beyond the scope of this study.

Slope %	Setback	Slope %	Setback
< 1%	35 feet	30 - 40%	85 feet
1 - 5%	45 feet	40 - 50%	105 feet
5 - 15%	55 feet	50 - 60%	125 feet
15 - 30%	65 feet	60 - 70%	150 feet

Conservation Lands

Reserves are well-represented in GreenInfo Network's California Protected Areas Database (CPAD). This dataset was used to mask areas precluded from conversion to vineyard due to reserve status. The Napa Land Trust acquired several new properties in 2018, and these were located by researching Assessor's records and represented by extracting parcels from the county-wide parcel dataset. There are a handful of deed restrictions and easements on portions of parcels (some related to the 60/40 rule) that were researched with the assistance of Brian Bordona and John Tuteur. These were hand-digitized based on georeferenced project planning documents.

Farmland

California Department of Conservation (CDC) farmland mapping is based on soils and observed land uses (McLeod, 2018). Soil types grouped as "higher-quality farmland" are likely most desirable for

agriculture; however a substantial portion of recent development has occurred on lands classified by CDC as "grazing" and "other." Vineyard conversion projects over the past 25 years have often occurred in soil classified as "other." Trucking in of topsoil and other emerging methods for growing in difficult locations make it impossible to rule out most soil types from potential development in the near future. See appendix 2 for more information on this dataset.

Soils

While soils can be an important consideration for agriculture, the potential for wine grapes to be grown on poor soils and the emerging practice of covering unsuitable soils with better material from off-site locations for agricultural development means that virtually any area meeting other criteria could be planted. With this in mind, analyses were inclusive of most soil types. Areas with serpentine-associated plant communities in the northeastern part of Napa County were excluded from the "developable" category.

Wetlands

Wetland data distributed by US Fish and Wildlife Service (USFWS) were used to model wetlands in this analysis. This dataset has mixed resolution and is not guaranteed for completeness. The source data were subset to exclude riparian zones, which have overriding setback protections provided by local and state policy, represented in this analysis by water body data and buffers on USGS blueline streams.

Parcels

Napa Assessor's parcel data were cleaned and processed for analysis. Geometry was repaired. For small parcel analysis, polygons with duplicate parcel numbers were dissolved into single polygons and railroad parcels were removed before performing a one-to-one spatial join with zoning data. For county-wide parcel-scale "developable" analysis, gaps were filled before intersecting with other county-wide datasets to prevent data from dropping out of the analysis.

60/40 Rule Deed Restrictions and Conservation Easements

A handful of conservation easements and deed restrictions related to the 60/40 rule were shared as geospatial data by the County of Napa, and the remainder were researched by identifying all projects were wildland was converted to agriculture in water supply drainages since 1993 and looking up deed documents at the Napa Assessors office.

Ratio and Percentage-based Policy Proposals

California Environmental Quality Act (CEQA) requirements and Public Resources Code § 21083.4 allow counties to enforce 2:1 mitigation for canopy removal, preferably on site, with the possibility of counting toward mitigation lands that may be undevelopable due to local policies, such as slope limits and stream setbacks. It is not possible to predict or model off-site mitigation with any confidence. Possible on-site outcomes and the difference between allowing mitigation on undevelopable lands - or not - can be evaluated once a model of developable area is created.

Small Areal Discrepancies

There are small differences in area among tallies presented here which arise from source datasets having slightly different extents or other minor issues. For example, Thorne (2004), CDC FMMP (2016), and County of Napa parcels (2019) datasets each have unique edges at the periphery of the county that do not match. Thorne has no polygon covering Napa Bay, whereas zoning data are continuous across

this area. Due to these and other mismatches, there may be small discrepancies when summarizing data. They should be in the range of 0 to 5 percent of the total.

Analysis Steps

Step 1. Base model: Existing constraints to development.

To create a base model of lands available for agricultural development under existing constraints, subtract unavailable areas from Napa County. Areas subtracted include:

Unavailable Area	Data	Source	Notes
Slopes >30%	LiDAR	Napa County	Geoprocessing
Existing vineyards	agriculture_public	Napa County, hand-digitized update	Filter non-vyrds; include fallow as vyrd (most are replanting); buffered to account for access roads
Serpentine soils	Napa Veg	Napa County / UCD / Thorne	Extract serpentine-associated veg areas
Reserves	CA Protected Areas Database 2018a	GreenInfo Network	
Easements and new reserves	Napa Land Trust	Hand-digitized	Complete through mid-2018
Deed restrictions	Researched in 2018	Napa County	In collaboration with Bordona; Tuteur
60/40 rule areas	Hand-digitized	Estimate parcels affected with post-1993 vyrds in municipal watersheds	Vyrd existing in 1993 doesn't follow 60/40
Roads	Roads	Napa County	Apply 60' buffer
Railroads	Railroads	Napa County	Apply 50' buffer
Water bodies	napa_wtr_bodies, Napa Veg	Napa County, UCD/Thorne	
Napa County stream setback requirements	(1) Streams layer and (2) 60' setback buffer	(1) NHD, (2) Napa County Hillside Ordinance	Apply 60' buffer for approximation of real impacts
Areas too small to be planted	Cull from output	Geoprocessing	<1,000 ft^2 removed
Homes, yards, driveways	Cull from output	Hand-digitized	Adds up to about 1,500 ac countywide, mostly in AP

Notes
Pending developments are included in estimate of developable area.

Step 2. Evaluate Land Cover Types.

Intersect each of the following layers with base model of developable area and quantify areas:

Parameter	Data	Source	Question
Oak woodland, conifer, chaparral…	Napa Veg	Napa County / UCD / Thorne	How much of each vegetation cover type is potentially plantable?
Soil suitability for agriculture	Farmland Mapping and Monitoring Program	CA Department of Conservation	Merge all ag-quality categories
Land Use Zoning		Napa County 2013	How much area in each zone is developable?

Step 3. Evaluate proposed percentage and ratio policies and stream setbacks.

Export geospatial data to tables and model impacts of policy mathematically.

Topic	Data	Source	Notes
2:1 rule	Base model-Napa Veg intersection; computation	Manfree, Napa County / UCD / Thorne	Analyzed with and without mitigation allowed on undevelopable lands
3:1 rule	Base model-Napa Veg intersection; computation	Manfree, Napa County / UCD / Thorne	Analyzed with and without mitigation allowed on undevelopable lands
70% rule	Base model-Napa Veg intersection; computation	Manfree, Napa County / UCD / Thorne	Analyzed with and without mitigation allowed on undevelopable lands
85% rule	Base model-Napa Veg intersection; computation	Manfree, Napa County / UCD / Thorne model	Analyzed with and without mitigation allowed on undevelopable lands
60/40 rule	Base model-Napa Veg intersection, watersheds intersect	Manfree, Napa County / UCD / Thorne model	Analyzed with mitigation allowed on undevelopable lands
Reservoir setbacks	Base model-reservoir buffer intersection	Manfree , USGS	How much developable area is within 200', 500', and 1,000' of water supply reservoirs?
Wetland setback	Base model-wetlands intersection; computation	USFWS, UCD/Thorne	How much developable area is within 150' of wetlands?
Zero to five acre parcels	Parcels, base model	Napa County, Manfree	What is the relationship between 0 to 5 ac parcels, zoning, and developable area?

Step 4. Parcel analysis.

Parameter	Data	Source	Notes
Parcel-level impacts	Parcels & model	Napa County & analysis	% available acreage per parcel - intersection
Parcel-level impacts	Parcels & model	Napa County & analysis	Land use zones - intersection
Parcel-level impacts	Parcels & model	Napa County & analysis	Change in development potential (mathematical)
0 to 5 acre parcels	Parcels	Napa County	Subset parcels, dissolve by ASMT, hand-edit to clean

Section 4 - Discussion

The analysis presented in this report integrates information in a way that can be used to assess potential broad-scale outcomes of a variety of policy constraints. It explains the distribution of land types in Napa County and presents estimates of the upward limit of development given existing constraints and prospective policies.

The Bigger Picture

Considering the information presented here in the context of broader concerns is key to making it useful. Global trends in environmental ethics, climate, and economics are overarching trajectories in the debate over how to best manage local resources, and they should be central to the discussion.

Napa County presently has about 20,590 acres of vineyard in the Agricultural Preserve and 24,200 acres in the Agricultural Watershed zone. Particularly in the Agricultural Preserve, existing vineyards are the crown jewel of our region, and protecting them should be a top priority. The important question is not "How much more can we develop?" but rather, "How can we best preserve the value we have?"

Napa County has a unique legacy of conservation and preservation, achieving great success with the establishment of the Agricultural Preserve, the Hillside Ordinance, and the Flood Control Project. Each of these projects is rooted citizen advocacy, eventually being supported and implemented by government agencies. At the time these projects emerged, they were controversial, bitterly fought, and took years to finalize. These projects have demonstrated that citizen action, when channeled effectively and combined with science, can result in local agency leadership. Thanks to these projects, Napa County's agencies have a remarkable capacity for resource stewardship and are running exemplary programs.

The current debate over conversion of wildlands to vineyard and other uses has many similarities to earlier campaigns. It is citizen-led, involves a lively debate among stakeholders, and will require careful policy-making and implementation to get right. It differs in one important way, however: the debate over wildland conversion exists with the backdrop of global climate change.

Climate change is already affecting crop quality (e.g., Jones et al. 2005), though it does not yet seem to be influencing planting decisions in Napa County. There are many adjustments farmers can make to mitigate climate change impacts, reduce carbon emissions, and increase carbon storage (Mira de Orduña 2010, Mozell 2014, Neethling et al. 2017). In order to protect existing high-value farmlands into the future, every opportunity should be taken to maximize carbon storage and minimize emissions.

Climate change considerations:

- Climate change projections for Napa County predict that the region will become increasingly unfavorable for high-value wine grapes in this century (Jones 2007, Mozell 2014).

- Climate change is raising daily low temperatures faster than daily highs (Karl et al. 1993, Davy et al. 2016), and winters are warming faster than summers (Cayan et al. 2008); these shifts affect growing degree days and crop quality.

- California's fog bank is expected to shrink (Johnstone and Dawson 2010, Torregrosa et al. 2013)

- Species presence and habitat connectivity are required to facilitate movement as temperatures shift and plants and animals must relocate to persist (Heller and Zavaleta 2009, Torregrosa et al. 2013).

- Increased carbon storage in stable sinks, such as living trees, can slow the effects of climate change. The retention of existing forests is an effective strategy because carbon is retained and increases as trees grow (Pregitzer and Euskirchen 2004).

Climate change is sometimes characterized as a looming monstrosity which is causing, or will cause, disasters of monumental scope. I suggest that the more subtle day-to-day effects will ultimately drive the biggest changes in patterns of settlement, agriculture, and economy. For example, slightly more intense storms will frequently cause minor increases in erosion, landslides, and road damage, and leave less time for groundwater infiltration in Napa's steep drainages (Battany and Grismer 2000). Slightly higher high and higher low temperatures will shift growing degree days, affecting crop quality, suitability, and pest success (Caffarra et al. 2012). At first, these small changes will be inconvenient. Over time, they will become increasingly expensive to correct and - eventually - they will transform land use.

Particularly in light of climate change, continued conversion of wildlands to agriculture in lower quality farmland areas is questionable. Low-quality and grazing lands, where most conversion of wildland to vineyard is presently occurring, are more challenging to farm. There are fewer grape varietals suitable for these locations, yields are lower that they would be in higher-quality locations, and wildland-urban interface problems, such as fire, can occasionally disrupt production. These areas are more likely to have groundwater limitations. Their climates are less temperate than the floor of Napa Valley as they are not influenced as much by coastal processes. For all of these reasons, lower-quality lands will be the first to become unprofitable as climate change impacts increase.

Continuing to remove native vegetation from low-quality and grazing land types not only depletes Napa County's best available carbon store and limits species movement, it does so in areas that will be the first to become untenable for farming as climate change progresses. This lose-lose situation should be avoided with policy that better protects wildlands and supports resilience. We can best preserve existing value by focusing on retaining forests for carbon storage and working aggressively toward emissions reduction. Saving trees is the same thing as saving vineyards.

Policy Development

Any new policy should be science-based, enforceable, and have on-the-ground impacts which substantively exceed the protections of current rules. Existing rules (State of California 1970; 2004) require two-to-one (66%) oak canopy mitigation, and retention of 60% of canopy and 40% of shrublands in sensitive water supply drainages, which Napa County tends to implement on-site, so this is the floor for meaningful new conservation policy.

Ratio-based and percentage-based mitigation requirements are different expressions of the same mathematical concept. A 2:1 rule is a 66 percent rule, and a 3:1 ratio is a 75 percent rule. The ratio-based "2:1" language is inherited from statewide regulations, but it is important to recognize that having both a ratio-based and percentage-based mitigation requirement is pointless if other factors (such as

whether mitigation is permitted on undevelopable lands) are held constant, and confusing if they are not. A straightforward way to structure new policy would be to adopt a single rule that is more stringent than existing rules.

Center for Biological Diversity recommends an ordinance that (1) requires retention of a minimum of 90% of existing forests and woodlands, (2) strictly limits development to slopes with less than 30% grade, (3) strongly favors on-site mitigation that leaves undeveloped areas intact, or would require 5:1 off-site mitigation within the watershed, or 10:1 mitigation outside the watershed in a location as nearby as possible (CBD 2019).

These recommendations are in-line with this report, which demonstrates that allowing conservation to occur within undevelopable areas seriously undermines its effectiveness. Important water supply watersheds including Bell Canyon, Hennessey, Rector, and Milliken have proportionally large areas of chaparral and conifer cover, and less oak. To protect these water supplies, adopting broad policies that protect all land cover types and/or increasing protections to water supply watersheds is recommended.

Future directions

This study could be expanded and complemented with additional analyses. Some potential directions include water supply watershed analysis, carbon storage estimates, historical conditions, or an analysis of land cover in undevelopable areas.

A more in-depth study of water supply watersheds to inform policy would be helpful. A GIS analysis paired with in situ water quality data would be ideal.

It may be possible to estimate carbon storage using the Thorne vegetation dataset and/or a LiDAR point cloud, if available.

An estimate of how current land cover compares proportionally to historical conditions could be completed by combining San Francisco Estuary Institute historical ecology data for the Napa Valley with Thorne vegetation data for wildland areas and interpolating non-conforming polygon values in rural areas.

As 30 to 50% slope areas can potentially be developed with exceptions to policy, it could be relevant to evaluate land cover in these lands.

Factors not addressed by this analysis

There are many considerations related to development that are only possible to evaluate at the site scale, on a project-by-project basis. This county-scale analysis represents broad trends and, with luck, discrete errors will tend to cancel each other at the scale of analysis. The methods section of this report provides a basis for reproduction, comparison, and critique by stating assumptions and rationale.

This assessment does not rate the relative quality of lands for carbon storage or conservation value, and it does not consider the presence of special-status species, accessibility, or willingness of owners to sell or develop properties. This report is intended to be considered together with local expert knowledge and assessments of habitat value, landscape connectivity, hydrology, etc.

No attempt is made here to represent development likelihood, which is influenced by many factors such as water availability, microclimate, sun exposure, and remoteness. For individual projects, these

factors are important considerations, however, they are challenging to model at the county scale. Development pressure could be estimated in a follow-up study, but even then would be impossible to predict if or when individual properties may be developed.

Policy effects are not analyzed in tandem with one another as their interactions are best considered at the site scale. At the county scale, it is more helpful to think about comparative policy outcomes.

On-the-ground conditions may have overlap between policy outcomes and land cover types. It may be that the same square foot of ground is precluded from development by slope, stream setback, and canopy retention requirements.

When adjacent parcels have the same owner, mitigation can be applied to the adjacent parcels as if they are one parcel. There is no systematic way to model this outcome, as ownership changes through time and ownership data are not readily available.

Limitations and disclaimer

Information presented here is intended to provide a big-picture, county-scale review of land use and land cover, and not to describe precise conditions on any given property or site. Modeling results are affected by data availability, data accuracy, and data quality. Spatial information is inherently dynamic and can be expected to change over time. It is the responsibility of users to understand data limitations and to use information appropriately. Data were generated in a conscientious, attentive manner and are reasonable estimates; however, data and related graphics are not legal documents and are not warrantied for accuracy, reliability, or completeness.

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Appendices

Appendix 1. California Department of Conservation Farmland Mapping and Monitoring Program

California Department of Conservation (CDC) Farmland Mapping and Monitoring Program (FMMP) classifications were grouped in this analysis. The "Higher quality farmland" category seen in this report includes: prime farmland, farmland of statewide importance, unique farmland, and farmland of local importance.

The following information describing CDC categories has been quoted directly from the CDC website and is included for the reader's convenience (accessed February 2019): https://www.conservation.ca.gov/dlrp/fmmp/Pages/Map-Categories,-Criteria,-and-Data.aspx

Important Farmland Categories

FMMP's study area is contiguous with modern soil surveys developed by the US Department of Agriculture (USDA). A classification system that combines technical soil ratings and current land use is the basis for the Important Farmland Maps of these lands. Most public land areas, such as National Forests and Bureau of Land Management holdings, are not mapped.

The minimum land use mapping unit is 10 acres unless specified. Smaller units of land are incorporated into the surrounding map classifications. In order to most accurately represent the NRCS digital soil survey, soil units of one acre or larger are depicted in Important Farmland Maps.

For environmental review purposes under CEQA, the categories of Prime Farmland, Farmland of Statewide Importance, Unique Farmland, Farmland of Local Importance, and Grazing Land constitute 'agricultural land' (Public Resources Code Section 21060.1). The remaining categories are used for reporting changes in land use as required for FMMP's biennial farmland conversion report.

Prime Farmland

> Farmland with the best combination of physical and chemical features able to sustain long term agricultural production. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for irrigated agricultural production at some time during the four years prior to the mapping date. Download information on the soils qualifying for Prime Farmland. More general information on the definition of Prime Farmland is also available.

Farmland of Statewide Importance

> Farmland similar to Prime Farmland but with minor shortcomings, such as greater slopes or less ability to store soil moisture. Land must have been used for irrigated agricultural production at

some time during the four years prior to the mapping date. Download information on the soils qualifying for Farmland of Statewide Importance.

Unique Farmland

Farmland of lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated, but may include nonirrigated orchards or vineyards as found in some climatic zones in California. Land must have been cropped at some time during the four years prior to the mapping date.

Farmland of Local Importance

Land of importance to the local agricultural economy as determined by each county's board of supervisors and a local advisory committee. Download a complete set of the Farmland of Local Importance definitions in PDF format. In some counties, Confined Animal Agriculture facilities are part of Farmland of Local Importance, but they are shown separately. The status of each county regarding Confined Animal Agriculture is available in this spreadsheet.

Grazing Land

Land on which the existing vegetation is suited to the grazing of livestock. This category was developed in cooperation with the California Cattlemen's Association, University of California Cooperative Extension, and other groups interested in the extent of grazing activities.

Urban and Built-up Land

Land occupied by structures with a building density of at least 1 unit to 1.5 acres, or approximately 6 structures to a 10-acre parcel. This land is used for residential, industrial, commercial, construction, institutional, public administration, railroad and other transportation yards, cemeteries, airports, golf courses, sanitary landfills, sewage treatment, water control structures, and other developed purposes.

Other Land

Land not included in any other mapping category. Common examples include low density rural developments; brush, timber, wetland, and riparian areas not suitable for livestock grazing; confined livestock, poultry or aquaculture facilities; strip mines, borrow pits; and water bodies smaller than forty acres. Vacant and nonagricultural land surrounded on all sides by urban development and greater than 40 acres is mapped as Other Land.

Appendix 2. Napa County/ James Thorne - Vegetation Map of Napa County

For the purposes of this analysis, land cover data created by James Thorne were used to remove undevelopable areas such as open water and serpentine soils, as serpentine-associated vegetation is a reliable proxy for soil type. These data were also used to estimate vegetation cover and type for oak, broadleaf non-oak, conifer, and chaparral categories.

The Thorne dataset is detailed beyond the needs of this study. Specific land cover types were grouped to support a general analysis (table 16, below). See literature for complete methods for the creation of the Vegetation of Napa County dataset (Thorne 2004).

Map Key (map next page)

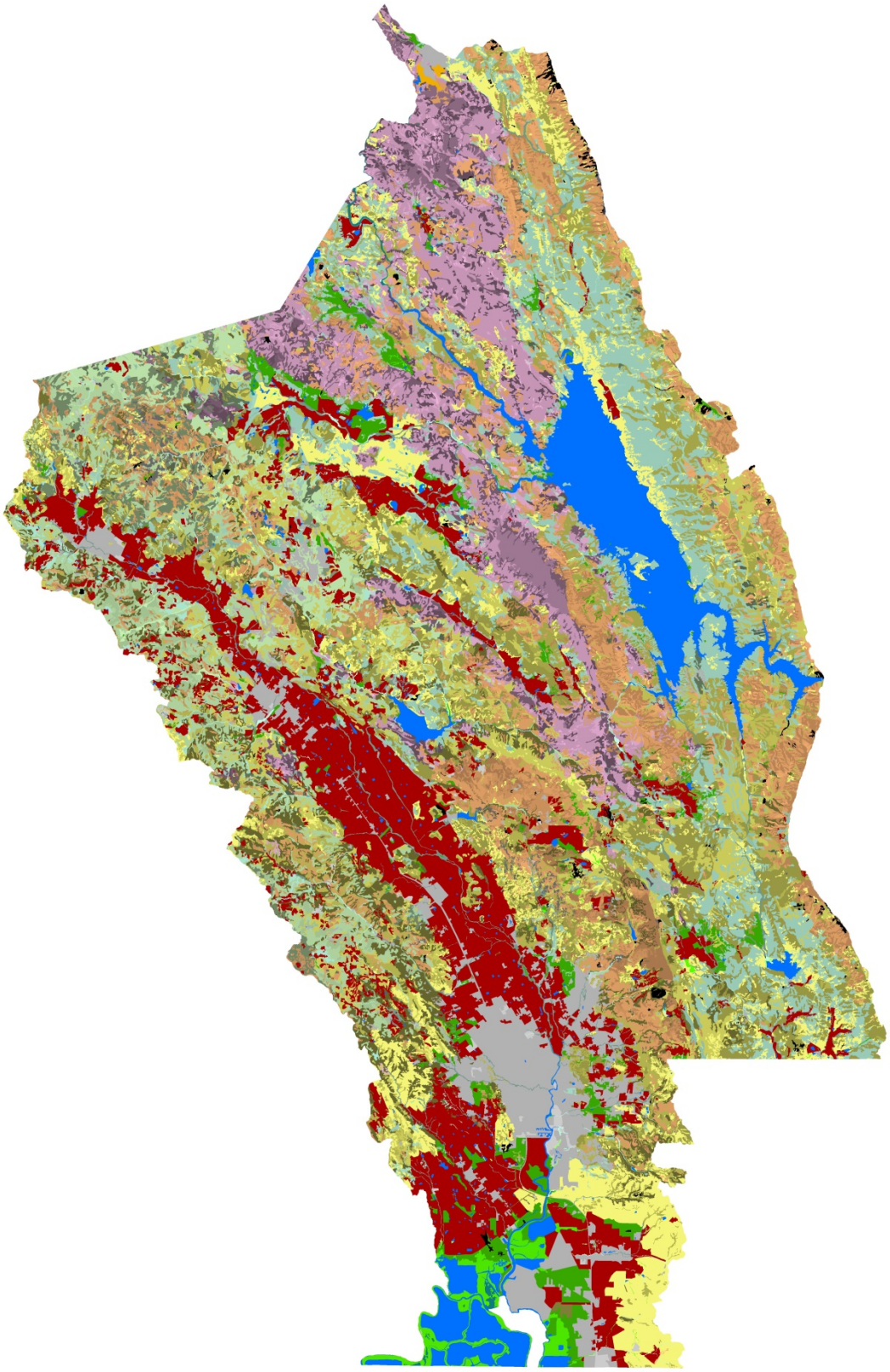

Figure 16. Vegetation of Napa County. Thorne et al. 2004. Key - previous page.

Table 19. Napa County Vegetation

Categories: Thorne, numbered; Manfree, bold.	Acres
Agriculture	**64,642**
9200 - Agriculture	64,642
Broadleaf non-oak	**20,338**
1100 - Winter-Rain Sclerophyll Forest & Woodlands	620
1101 - California Bay - Coast Live Oak - (Madrone - Black Oak Big Leaf Maple)	18,343
1123 - Eucalyptus Alliance	408
3201 - White Alder (Mixed Willow - California Bay - Big Leaf Maple) Riparian	967
Chaparral	**61,244**
1124 - Tanbark Oak Alliance	245
4300 - Sclerophyllous Shrubland	3,277
4301 - Scrub Interior Live Oak - Scrub Oak - (California Bay - Flowering Ash - Birch Leaf Mountain Mahogany - Toyon - California Buckeye) Mesic E	11,057
4302 - Mixed Manzanita - (Interior Live Oak - California Bay - Chamise) West County	8,813
4321 - Chamise Alliance	30,790
4322 - Chamise - Wedgeleaf Ceanothus Alliance	7,019
4501 - Coyote Brush - California Sagebrush (Lupine spp.)	42
Conifer	**38,786**
2104 - Foothill Pine / Mesic Non-serpentine Chaparral	930
2121 - Foothill Pine Alliance	1,763
2122 - Knobcone Pine Alliance	5,943
2123 - Ponderosa Pine Alliance	168
2126 - Sugar Pine Alliance or Sugar Pine / Canyon Oak	3
2127 - California Juniper Alliance	2
2201 - Coast Redwood - Douglas Fir / California Bay	2,880
2222 - Douglas Fir Alliance	17,390
2224 - Douglas Fir - Ponderosa Pine Alliance	9,382
2230 - Coast Redwood Alliance	324
Grasslands	**51,762**
7100 - Upland Annual Grasslands & Forbs	12,169
7101 - Native Grassland Restoration Sites	256
7120 - California Annual Grasslands Alliance	39,337
Oak predominant	**149,221**
1122 - Canyon Live Oak Alliance	567
1201 - Coast Live Oak - Blue Oak - (Foothill Pine)	26,544
1202 - Interior Live Oak - Blue Oak - (Foothill Pine)	18,089
1221 - Coast Live Oak - (Foothill Pine)	13,187
1222 - Interior Live Oak - (Foothill Pine)	5,299
1223 - Mixed Oak (Foothill Pine - Ponderosa Pine)	28,830
3101 - Valley Oak - (California Bay - Coast Live Oak - Walnut - Ash) Riparian	5,721

3102 - Valley Oak - Fremont Cottonwood - (Coast Live Oak) Riparian	520
3121 - Black Oak Alliance	2,221
3122 - Blue Oak Alliance	44,220
3123 - Valley Oak Alliance	2,889
3124 - Oregon White Oak Alliance	1,136
Rock outcrop	**1,738**
9001 - Rock Outcrop	1,738
Serpentine	**53,494**
2105 - Foothill Pine / White Leaf Manzanita - Leather Oak - (Chamise -Ceanothus spp.) Xeric Serpentine	7,958
2106 - Foothill Pine / California Bay - Leather Oak - (Rhamnus spp.) Mesic Serpentine	7,280
2124 - McNab Cypress Alliance	2,415
2125 - Sargent Cypress Alliance	2,044
3202 - (Brewer Willow) Poorly Developed Serpentine Riparian	277
4303 - Leather Oak - White Leaf Manzanita - Chamise Xeric Serpentine	26,994
4304 - Leather Oak - California Bay - Rhamnus spp. Mesic Serpentine	4,395
7130 - Native Serpentine Grasslands	2,087
9003 - Serpentine Barrens	44
Wetland	**5,089**
3221 - Mixed Willow Super Alliance	539
6402 - (Bulrush - Cattail) Fresh Water Marsh	271
6403 - (Carex spp. - Juncus spp. - Wet Meadow Grasses)	275
6501 - Saltgrass - Pickleweed	3,573
9002 - Riverine, Lacustrine, and Tidal Mudflats	432
Water	**28,815**
9400 - Water	28,815
Urban	**26,465**
9100 - Urban or Built-up	26,465
Vacant	**1,787**
9300 - Vacant	1,787
Unidentified	**1,571**
9999 - Unidentified	1,571
Total Acres:	504,951

Appendix 3. Amber Manfree Curriculum Vitae

Education

Ph.D., Geography, University of California, UC Davis, September 2014.
Dissertation: Landscape Change in Suisun Marsh
Available: https://pqdtopen.proquest.com/doc/1629429650.html?FMT=ABS
Advisor: Dr. Peter Moyle
Awards: 2015 Kinsella Memorial Prize in recognition of the Outstanding Graduate Research Dissertation in the College of Agricultural and Environmental Sciences at UC Davis

Master of Arts, Geography, UC Davis, December 2012. Specialty in GIS and Geographic Techniques, minor in Plant Ecology
Advisor: Dr. Peter Moyle

Geographic Information Systems (GIS) Competency Certificate, Santa Rosa Junior College, 2009.

Bachelor of Arts, Environmental Studies, Sonoma State University, September 1999. Emphasis in Media Studies.

Research Experience

Postdoctoral research, UC Davis, 2014 - 2018. Research in ecological effects of drought in the Sacramento-San Joaquin Delta. Research in Floodplain Ecology and fish ecology in Suisun Marsh.

Doctoral Research, UC Davis, 2012 - 2014. Read and synthesized historical record for Suisun Marsh, described 200 years of landscape change based on the anthropological record, explorers journals, the map record, and other sources. Designed animated maps to communicate content of the Suisun Marsh Fish and Invertebrate Study dataset.

Masters Research, UC Davis, 2006 - 2012. Characterized hydrogeomorphic change in Suisun Marsh based on the map record and other sources.

Research Assistant, Center for Watershed Sciences (CWS), UC Davis, 2011 - 2014. Editing, cartography, and graphic design for Suisun Marsh: Ecological History and Possible Futures (book) and California Drought Summit program. Microsoft Access database management and GIS support for research and CWS publications.

Research Assistant, Landscape Analysis and Systems Research Laboratory, UC Davis, 2006 - 2011. Modeled landscape-scale impacts of water use patterns in residential neighborhoods.

Publications

Opperman, Jeffrey J., Peter B. Moyle, Joan L. Florsheim, Eric W. Larsen, and Amber D. Manfree. Floodplains: processes and management for ecosystems. UC Press, Berkeley, (2017).

Baumsteiger, Jason, Robert E. Schroeter, Teejay A. O'Rear, Jonathan D. Cook, Amber D. Manfree and Peter B. Moyle. Factors affecting distribution and abundance of a trio of invasive Black Sea jellyfish in San Francisco Estuary, California. PLOS ONE (in Press).

Manfree, Amber D. Napa County strings together a 'living' river. July 2015. California WaterBlog, UC Davis Center for Watershed Sciences. http://californiawaterblog.com/2015/07/29/napa-county-strings-together-a-living-river-2/

Moyle, Peter B., Amber D. Manfree, and Peggy L. Fiedler, editors. 2014. Suisun Marsh: Ecological History and Possible Futures. UC Press, Berkeley, CA.

Manfree, Amber D. *in* Moyle, Peter B., Amber D. Manfree, and Peggy L. Fiedler, editors. 2014. Historical Ecology of Suisun Marsh. UC Press, Berkeley, CA.

Moyle, Peter B., Amber D. Manfree, and Peggy L. Fiedler. 2013. The Future of Suisun Marsh: Balancing Policy with Change. San Francisco Estuary and Watershed Science, 11(3).

Manfree, Amber D. Drought journal: Search for Sierra fish goes from bad to worse. August 2014. California WaterBlog, UC Davis Center for Watershed Sciences. http://californiawaterblog.com/2014/08/18/drought-journal-search-for-sierra-fish-goes-from-bad-to-worse/

Manfree, Amber D., and Peter Moyle. May 2014. Planning for the inevitable at Suisun Marsh. May 1, 2014. California WaterBlog, UC Davis Center for Watershed Sciences. http://californiawaterblog.com/2014/05/01/planning-for-the-inevitable-at-suisun-marsh/

Presentations and Posters

Manfree, Amber D. Warming up to (Climate) Change. How studying landscape change can help communities adjust to a shifting environment. Presented at the 2016 Okanagan Water Board Annual Meeting.

Manfree, Amber D. Exploring a long-term fish dataset with ArcGIS animation tools. Presented at the at 2015 Annual ESRI User Conference.

Manfree, Amber D. The Fishes of Suisun Marsh: Exploring and Communicating 35 years of research with data animations. Presented at the at 2015 Annual California Geographical Society Conference.

Manfree, Amber D. Landscape-scale aquatic reconciliation in the North Delta Arc. Presented at the 2015 Annual Meeting of the California-Nevada Chapter of the American Fisheries Society.

Manfree, Amber D. Garden Nurseries and Trophic Relays: Spatial partitioning by fish size class in the Arc reflects higher juvenile recruitment and foraging success in regions of high pelagic food production. Presented at the 2015 Interagency Ecological Program Workshop.

Manfree, Amber D., Peter B. Moyle. Thirty-Five Years of Fish Studies in Suisun Marsh: Perspectives and Animations. Presented at the 2014 8th Biennial Bay-Delta Science Conference.

Manfree, Amber D. A new look at the fishes of Suisun Marsh. Presented at the 2014 Annual Meeting of the California-Nevada Chapter of the American Fisheries Society.

Manfree, Amber D., Peter B. Moyle, Peggy L. Fiedler. Suisun Marsh, past and prospects: Highlights from the forthcoming book with UC Press. Presented at the 2013 11th Biennial State of the Estuary Conference.

Manfree, Amber D. Suisun Marsh historical ecology: Notoriously swampy and overflowed lands. Presented at the 2012 7th Biennial Bay-Delta Science Conference.

Manfree, Amber D. Historical Ecology of Suisun Marsh. Poster presented at 2011 Annual California Geographical Society Conference.

Manfree, Amber D. Modeling wet and dry weather water quality in Sacramento County's urban residential areas. Presented at the 2010 Annual California Geographical Society Conference.

Manfree, Amber D., Andrew Bale, Steven Greco, Loren Oki, Darren Haver, Jay Gan, Sveta Bondarenko. Modeling the effects of landscape best management practices on water quality in urban residential areas. Presented at the2010 239th Annual American Chemical Society Conference.

Manfree, Amber D., Steven Greco, Andrew Bale. Modeling the effects of household-scale BMPs in urban residential zones. Presented at the 2009 Annual Meeting of the American Association of Geographers.

Cartographic work

Comprehensive Conservation and Management Plan. 2016. San Francisco Estuary Partnership.

State of the Estuary Report. 2015. San Francisco Estuary Partnership.

Connolly Ranch welcome map interpretive signage. 2014. Napa Land Trust and Connolly Ranch.

The Shifting Cultural Landscape of the San Francisco Bay Area, 1772 - 1846. 2013. Self-published.

Watersheds of California. 2010. Self-published.

Teaching Experience

Instructor

Introduction to GIS, 2017, 2018, and 2019 courses for the UC Davis Extension
GIS for Watershed Analysis, 2018 course for the UC Davis Extension
Communicating with Maps, 2018 course for the UC Davis Extension
GIS Methods for Hydrology, Spring 2016 and Summer 2014
Practical GIS for Field Research, Fall 2012 and Spring 2013

Teaching Assistant

Introduction to Geographic Information Systems, Fall 2011
Site Ecology for Landscape Architects, Spring quarters 2007 - 2010
History of Landscape Architecture, Winter 2007

Curriculum Development

Led development of GIS curriculum plan for undergraduate studies at UC Davis; effort sponsored by James Quinn at the UC Davis Information Center for the Environment, Fall 2009

Guest Lectures

Careers in GIS. September, 2018. Invited by Professor Alison McNally to lecture undergraduate students at Cal-State Stanislaus.

How Historical Ecology informs our Sense of Place. July, 2017. Invited by instructor Sahoko Yui to lecture to UC Berkeley Landscape Architecture students about applying historical research to Landscape Design.

What does it mean to design with nature? November, 2012. Invited by Dr. Claire Napawan to lecture to UC Davis Landscape Architecture students in introductory course. Lectured on environmental ethics, landscape change geography, and reconciliation ecology.

GIS, GPS, and Cartography. June 2012. Napa Valley Personal Computer Users Group.

Genetics and Evolution for Landscape Architects, Spring 2010. Guest lecture to students in Site Ecology for Landscape Architects.

Community Service

Suisun Marsh Complete Marsh Project, 2017, 2018

Suisun Marsh Fish and Invertebrate Study field sampling, 2008-2016.

Bodega Bay Annual Field Survey volunteer, 2009, 2010, 2011, 2014, 2017

North Bay Fish Study (Hobbs; Napa, Sonoma, and Petaluma creeks), 2016

Outdoor education modules for Napa Resource Conservation District student field trips, 2014, 2015

Organized tour of Napa River restoration projects for UC Davis affiliates, 2015

South San Francisco Bay Salt Ponds Fish Study, 2014

Pine Creek Annual Fish Survey (Modoc County), 2010

Putah Creek Annual Field Survey, 2009