CITY OF BELMONT
CITY COUNCIL AND BELMONT FIRE PROTECTION DISTRICT BOARD OF DIRECTORS

CITY OF BELMONT

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CITY COUNCIL SPECIAL MEETING AGENDA
Tuesday, September 26, 2023
6:00 PM
City Council Chambers
City Hall, One Twin Pines Lane, Belmont, California

The meeting will be broadcast live to Belmont residents on Comcast Cable Channel 27, streamed live via the City's website at www.Belmont.gov. The public may also attend the meeting in the City Council Chambers and address the council from the chambers.

PUBLIC COMMENT:

To maximize time for live public comment, we encourage members of the public to provide comments by joining the City Council meeting via Zoom : For web, visit https://belmont-gov.zoom.us/ select "Join" and enter **Meeting ID: 95745673035**. Use the Raise Hand feature to request to speak. You may rename your profile if you wish to remain anonymous.

For dial- in comments, call *67 1-(669) 900-6833 (your phone number will appear on the live broadcast if *67 is not dialed prior to the phone number), enter **Meeting ID: 95745673035**, and press *9 to request to speak. All public comments are subject to a 3-minute time limit unless otherwise determined by the Mayor.

If you wish to submit written public comment, you may send an email to cclerk@belmont.gov before the council considers the item. Please indicate the agenda item topic or agenda item number you wish to comment on in your email's subject line. Any public comment regarding agenda items that are received from the publication of the agenda through the meeting date will be made part of the meeting record, but will not be read during the Council meeting.

1. ROLL CALL

2. ITEMS OF BUSINESS
Persons wishing to orally address the Council on the items of business listed below will be given an opportunity to do so before or during the Councils consideration of the item.

3. CLOSED SESSION

A. CONFERENCE WITH LEGAL COUNSEL - EXISTING LITIGATION
Government Code Section 54956.9(d)(1), One case:

Joseph P. Cuviello v. City of Belmont et al., U.S. District Court, N.D. Cal. 23-cv-00029-LB, U.S. Court of Appeals, Ninth Circuit No. 23-16135

B. **CONFERENCE WITH LEGAL COUNSEL - ANTICIPATED LITIGATION**
Significant exposure to litigation under Government Code Section 54956(d)(2): one case
Letter threatening litigation dated June 22, 2023, from Greenfire Law, PC on behalf of Deniz Bolbol, Joseph
P. Cuviello and Friends of Waterdog Open Space

Attachment(s):
Letter threatening litigation

C. **CONFERENCE WITH LEGAL COUNSEL - ANTICIPATED LITIGATION**
initiation of litigation under Government Code Section 54956.9(d)(4):1 case

4. SPECIAL PRESENTATION

A. **Research and Development/Life Sciences - Understanding Biosafety Levels (BSL)**

5. ADJOURNMENT

If you need assistance to participate in this meeting, please contact the City Clerk at (650) 595-7414. Notification in advance of the meeting will enable the City to make reasonable arrangements to ensure accessibility to this meeting. Meeting information can also be accessed via the internet at: www.belmont.gov. All staff reports will be posted to the web in advance of the meeting, and any writings or documents provided to a majority of the City Council/District Board or Commission regarding any item on this agenda will be made available for public inspection in the City Clerk's Office, One Twin Pines Lane, during normal business hours and at the Council Chambers at City Hall, Second Floor, during the meeting.

GREENFIRE LAW, PC

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June 22, 2023

By Email and Certified Mail

Hon. Mayor Julia Mates
Hon. Vice Mayor Davina Hurt
Hon. Councilmember Tom McCune
Hon. Councilmember Gina Latimerlo
Hon. Councilmember Robin Pang-Maganaris
Emails: jmates@belmont.gov; dhurt@belmont.gov tmccune@belmont.gov; glatimerlo@belmont.gov; rmaganaris@belmont.gov

1 Twin Pines Lane
Belmont, CA 94002
CityCouncil@belmont.gov
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RE: Petition and Notice of intent to sue over the City of Belmont's failure to enforce legal protections of natural resources in the Waterdog Open Space.

Dear Hon. Mayor and Councilmembers:

I am writing on behalf of Deniz Bolbol, Joseph P. Cuviello, and Friends of Waterdog Open Space, a project of Humanity for Education, a 501(c)3 non-profit organization, to seek urgent action to address the significant deterioration of Belmont's open space areas caused by management practices which are not in conformance with the City of Belmont's current General Plan, Parks and Open Space Master Plan and Open Space Trail System Master Plan; the City's lack of maintenance of the Open Space and unchecked violations of City ordinances and trail use policies must be addressed. The severe erosion from washed out trails that dumped sediments into streams and culverts in the wake of last winter's storms are just one result of this ongoing problem. The City's failure to enforce adopted ordinances and open-space policies, together with inadequate maintenance of recreational trails, has damaged Belmont's natural resources, recreational opportunities, water quality, and public safety – and will continue to do so unless something is done. In addition, the City's current management practices are violating provisions of the Endangered Species Act by failing to protect the habitat of Mission Blue Butterflies and other species observed in the Open Space.

Friends of Waterdog Open Space is a grassroots advocacy group made up of individuals who live, work, and recreate in the City of Belmont's open spaces, parks, and neighborhoods, including Waterdog Lake and Open Space. Its members share deep concern for the declining condition and safety of the City's open space trails and biodiversity. As you may know, the San Francisco Peninsula is central to one of 36 global biodiversity hotspots, which are areas distinguished by exceptional levels of biodiversity but also significantly threatened by human habitation and development.[1] Preservation of Earth's natural diversity is critical not only for plants and wildlife, but also for human health and well-being. Waterdog Lake and Open Space is one of the few remaining natural places within Belmont, yet its ecological balance is impaired, and visitor safety is threatened, as a result of the City's failure to prevent damage to its sensitive habitat, soils, waterways, and trail system.

Friends of Waterdog Open Space is also concerned about the lack of public notice and transparency concerning dredging and trail repair work within the City's open spaces. While clearing sediments from culverts along Canyon Creek was necessary to address the immediate exigencies of drainage and flood control, the larger question of how to manage and prevent repetition of such severe erosion must not be treated as a forgone conclusion. Whether to rebuild or decommission flood-damaged trails requires careful planning and warrants public discussion and opportunities to comment. Allowing the continued use of trails in disrepair further erodes the trails and the natural ecosystems near them. Rebuilding or allowing usage of unauthorized trails that were never properly planned and designed in the first place may cause significant environmental impacts that require review under the California Environmental Quality Act (CEQA),[2] as well as water permits to address trails near creeks and going through creek crossings. Currently, multiple trails, including unauthorized trails, cross waterways – including the Belmont Creek. Alternatively, decommissioning problem trails and restoring vegetation would alleviate the need for expensive environmental review and construction and benefit the community through conservation of soils and wildlife habitat. It appears that the City has rebuilt and opened closed trails without any CEQA review.

Most recently, the City claims to have closed the following trails: "Chapparal trail from Elevator to John Brooks, Rambler from John Brooks to Finch, and Rambler from Ohlone to Canyon Creek." The City has been publicizing these trail closures since at least March 2023, three months ago. Yet to date, the trails remain open, subjecting citizens to unstable hillsides, significant risk of landslides, and worsening erosion problems – and with no environmental review to examine the impacts of re-opening these trails. Earlier this month, the City indicated that these "closed" trails would remain open for use for the next two to three months because Belmont does not have the resources, or inclination, to immediately address this situation. This inability or unwillingness to assign sufficient funds to address the increasingly heavy usage and associated impacts to the open space is an additional indication of Belmont's failure to adequately care for and manage this important public resource.

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[1] Conservation International, "Biodiversity Hotspots," https://www.conservation.org/priorities/biodiversity-hotspots (Last-visited April 4, 2023); See also Critical Ecosystem Partnership Fund, "California Floristic Province," https://www.cepf.net/our-work/biodiversity-hotspots/california-floristic-province (last visited April, 4, 2023).
[2] Public Resources Code §§ 21000 et seq.

Please regard this letter as a formal petition and 60-day notice of intent to sue. The City's actions and inactions are inconsistent with numerous provisions of the City's general plan, and have damaged city property and leased lands in violation of California's taxpayer waste law, Code of Civil Procedure section 526a. By failing to properly maintain trails and tacitly endorsing the unauthorized use (and use of unauthorized trails) and modifications of the open space trail system, including trails through streams beds and unauthorized stream crossings, the City has implicitly authorized discharges of pollutants into waterways in violation of the Porter Cologne Act,[3] and the federal Clean Water Act (CWA),[4] and enabled the disruption of sensitive habitat and species in violation of California Fish and Game Code section 1602, the California Endangered Species Act (CESA),[5] and the federal Endangered Species Act (ESA).[6] In addition, by authorizing and engaging in unnoticed and unpermitted dredging and trail work without first conducting an analysis of potentially significant effects on the environment, the City has violated CEQA.

REQUEST FOR NOTICE. In addition, Friends of Waterdog Open Space hereby requests notification, as an interested member of the public, of any and all new or ongoing open space management actions including but not limited to trail construction or maintenance and related volunteer programs and activities, including the cutting of or removal of vegetation and application of herbicides. We hereby request that the City provide notice at least seven days in advance of the commencement of any such projects by emailing Greenfire Law, PC at jblome@greenfirelaw.com and sbradford@greenfirelaw.com and Friends of Waterdog Open Space at deniz_b@yahoo.com.

I. Background

As of the writing of this letter, Waterdog Lake & Open Space (Waterdog) contains at least six illegal, unauthorized trails that slice through rare habitat and sensitive streams in the area. The map pictured below, and attached as **Exhibit A**, shows the location of these unauthorized trails depicted in yellow. These are trails that were constructed by private individuals, without any CEQA analysis or opportunity for public comment, yet the City has sanctioned the trails by allowing them to remain open and in use.[7] The ongoing use and continued construction of unauthorized trails has already caused and continues to further significant negative impacts on the surrounding environment, as discussed herein. Notably, some new trails that have been or are being built may not appear on Figure 1 (**Exhibit A**).

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3 Water Code division 7, §§ 13000 et seq.
4 33 U.S.C. §§ 1251 et seq.
5 Fish and Game Code §§ 2050 et seq.
6 16 U.S.C. §§ 1531 et se*q.*
7 Rather than decommissioning trails, the City has posted traffic signs on some unauthorized trails, effectively affirming their continued use.

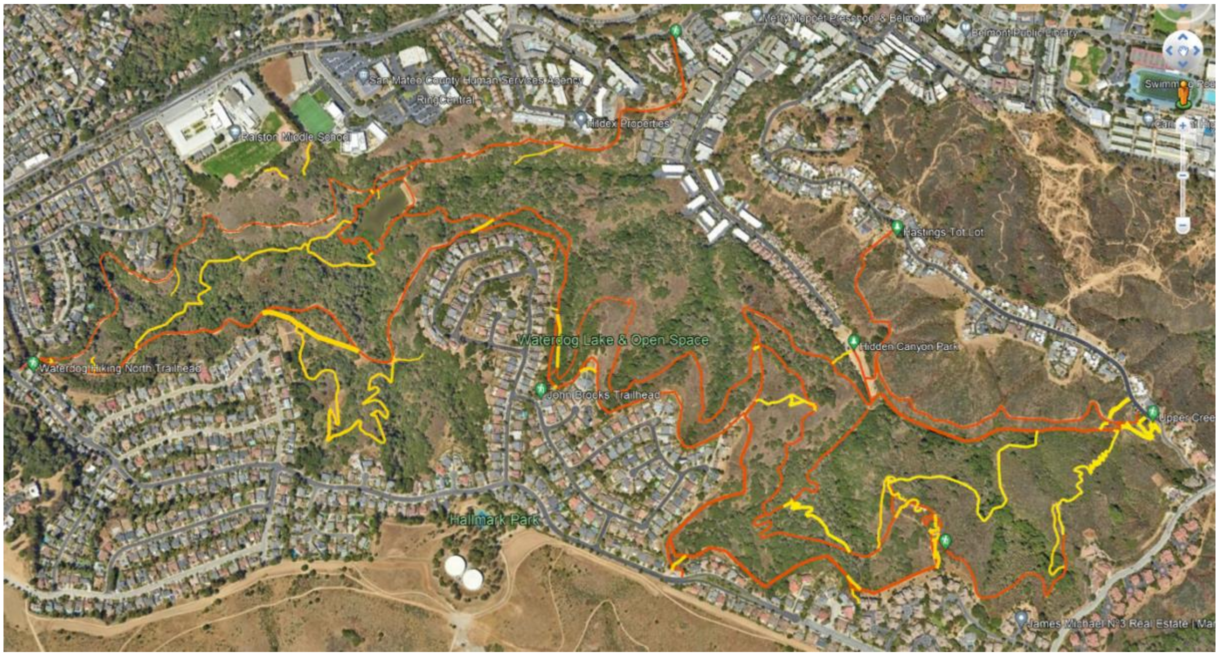

Fig. 1. Map of Waterdog Open Space trails (Exhibit A).

Trails at Waterdog Open Space, including most notably the unauthorized trail along Belmont Creek – as well as Olone, Lake Loop, Canyon Creek, Upper Canyon Creek, Finch, Chaparral, Rambler trails, and others – cut across multiple seasonal and ephemeral streams that feed into Waterdog Lake, Belmont Creek, and other waterways. Many of these trails are redundant trails cutting across the same waterways at multiple locations.

Over the past several years, the City has allowed mountain bikers to dig up and build trails across numerous streams within Waterdog Open Space. Many of these trails also pass through areas of ponding water and seeps and, in some areas, include modification of numerous rolling dips, rock-armored crossings, and causeways through chronically wet areas. These trails also cut through sensitive plant communities and riparian vegetation that provides important habitat for numerous species. Trails on steep hillsides have also destabilized soils and caused gully erosion. Impacts from these trails include significant erosion problems, potential impacts to sensitive species, and water quality impairment.[8] The most damaging is the trail that crosses the Belmont Creek in multiple locations and cuts through sensitive riparian habitat which is now declining in health due to invasive plants being brought in by human use. In fact, the City's own recent survey found that 28% of the trails in Waterdog exhibit medium to high soil erosion, not counting creek crossings, while nearly 20% of trails (one in five) are previously unmapped, user-created trails.[9]

Alarmed by the City's inaction, after numerous administrative complaints and requests for the closure of these unauthorized trails, Friends of Waterdog Open Space commissioned an

[8] City of Belmont, Draft Parks, Recreation, and Open Space Master Plan (PROS Plan), at 84-111, (June 2022).
[9] *Id*. at 101, 106.

independent biological resources consultant, Scott Cashen, M.S., to conduct an independent environmental assessment of the recreational trails in several open spaces within the City of Belmont. This study, entitled *Environmental Assessment of Recreational Trails in John S. Brooks Memorial Open Space Preserve, Waterdog Lake Park, and Hidden Canyon Open Space* (hereinafter "Cashen EA"), is attached as **Exhibit B**.[10] The Cashen EA examined three open space areas including Waterdog, the John S. Brooks Memorial Open Space Preserve, and Hidden Canyon Open Space (collectively "the study area"), which together comprise approximately 89% of the open space and undeveloped park area in the City of Belmont.[11]

The Cashen EA confirms that eroding and unauthorized trails in Waterdog are likely to impair water quality,[12] and also threaten areas that contain unique or irreplaceable remnants of biological diversity and numerous sensitive species.[13] Indeed, most of the natural vegetation throughout the study area is classified as "Sensitive Natural Communities" based on degree of scarcity and threats to their persistence,[14] including all three habitat types found in Waterdog: Blue Oak Woodland, Coastal Oak Woodland, and Valley Foothill Riparian.[15] The proliferation of trails also imperils wildlife by fragmenting habitat and increasing human activity, which can stress animals and impair critical life activities, such as feeding, watering, and breeding.[16] Some species, like snakes, are also placed at increased risk of being run over by high-speed bicyclists.[17]

Use of narrow hiking trails by mountain bikers also poses risk of injury to hikers and walkers. The Cashen EA reports finding evidence of mountain bike use on every trail it examined, including designated hiking trails that are too narrow to accommodate both hikers and bicycles.[18] Videos posted by mountain bikers and testimonials of hikers also attest to the fact that many bikers do not comply with the requirement to give right of way to pedestrians.[19] The increasing use of mountain bikes and ebikes on narrow single-track trails in areas where they are supposed to be prohibited is dangerous and poses a nuisance to other trail users.

By failing to act, and by sanctioning unauthorized uses and trails, the City has allowed the adverse impacts to grow steadily worse. Action is urgently needed to prevent further deterioration of Waterdog and damage to natural resources, and to prevent potentially

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[10] Scott Cashen, Environmental Assessment of Recreational Trails in John S. Brooks Memorial Open Space Preserve, Waterdog Lake Park, and Hidden Canyon Open Space ("Cashen EA")(April 2021), https://www.waterdogpreserve.org/cashen-environmental-assessment.
[11] Cashen EA at 1, 5.
[12] Cashen EA at 13-15.
[13] Cashen EA at 1, 8-11.
[14] Cashen EA at 7-8; citing California Dept. of Fish and Wildlife (CDFW), "Sensitive Natural Communities," https://wildlife.ca.gov/Data/VegCAMP/Natural-Communities - sensitive natural communities.
[15] City of Belmont, 2035 General Plan, Conservation Element, at 5-4 (Nov. 14, 2017).
[16] Cashen EA at 18-23.
[17] Cashen EA at 18.
[18] Cashen EA at 12, 20.
[19] *See e.g.*, "Waterdog - Safe, Sustainable and Equitable for All," https://www.waterdogpreserve.org/ (last visited May 19, 2023).

irreversible harm to Belmont's unique biological communities and sensitive species.

II. Environmental Impacts and Need for Action

The City's failure to protect open space areas and public trails from improper actions by users causes damage to city property, and impairs water quality, sensitive biological resources, and public safety.

A. Unauthorized trail construction and use impairs the biological resources of Waterdog Lake and Open Space

Waterdog Lake Open Space provides important habitat for a variety of protected and special status species and sensitive natural communities. The open space also serves as a vital wildlife corridor linking otherwise isolated habitat fragments into connected range that allows natural migration.

1. Sensitive Habitat

The primary plant communities comprising the vegetation in Waterdog Lake Open Space are sensitive natural communities, including Blue Oak Woodland, Coastal Oak Woodland, Valley Foothill Riparian, and Chamise-Redshank Chaparral.[20]

Notably, "oak woodlands have the richest wildlife species abundance of any habitat in California, with over 330 species of birds, mammals, reptiles, and amphibians depending on them at some stage in their life cycle."[21] Key threats to oak woodlands include human development and Sudden Oak Death, a disease that spreads through waterways.[22]

Riparian habitat too is known for its abundant biodiversity. More than 225 species of birds, mammals, reptiles, and amphibians depend on California's riparian habitats. Generally speaking, more species rely on riparian areas than any other habitat type, including many sensitive, threatened, and endangered species.[23] Riparian vegetation along waterways can also provide habitat connectivity corridors connecting otherwise fragmented islands of habitat, which is important for many species. The City's general plan also recognizes that the City's open space areas "provide valuable travel corridors for wildlife and increase wildlife population diversity."[24]

"California's native chaparral plant communities support exceptional biodiversity and provide critical ecological services …chaparral itself, has incredibly high biodiversity … with

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[20] Cashen EA at 7-8; City of Belmont, 2035 General Plan, Conservation Element, at 5-4 (Nov. 14, 2017).
[21] Cashen EA at 8.
[22] Cashen EA at 8, 16.
[23] National Research Council (NRC), Riparian Areas: Functions and Strategies for Management, at 109-10, The National Academies Press (2002), https://doi.org/10.17226/10327.
[24] City of Belmont, 2035 General Plan, Conservation Element, at 5-3 (Nov. 14, 2017).

most characteristic bird, mammal, and insect communities aligning with shrub cover. Thus, the loss of chaparral is an ecological impact of global significance (Cowling et al. 1996)."[25]

"Although often maligned as a useless or even dangerous because of concerns over fire hazard, chaparral ecosystems provide critical ecosystem services through their roles in erosion control, hydrology, biomass sequestration, and preservation of biodiversity... Short fire-return intervals of less than 10–15 years present an increasing threat to chaparral ecosystems by eliminating shrub regeneration and leading to type-conversion to non-native annual grasslands."[26]

In contrast, unauthorized and poorly designed trails that disturb soils and displace vegetation have an adverse impact on the diversity and resilience of sensitive habitats and the wildlife by fragmenting habitat, creating barriers to wildlife, and allowing invasive species to take root.[27] Habitat fragmentation affects species differently depending on their range and habitat needs, but can cause subgroup isolation that impairs reproduction. Adding new trails imposes additional barriers for wildlife that needs to cross a trail to access water or foraging areas. Invasive species, meanwhile, once established often outcompete native species and undermine ecological integrity and biodiversity. These are significant adverse impacts on native biodiversity, especially where the habitat affected, as here, is already a small fragment of the biotic communities that once thrived across the peninsula.

Excessive trail density also impairs the biodiversity and conservation values of the Open Space. New trails and shortcuts through previously intact vegetation creates new inroads for invasive species that reduces the stability of native plant communities. For example, stands of pampas grass that are already established along the Brooks trail have spread into new areas due to the City's mismanagement.[28] Increased trail density also impairs wildlife habitat and travel corridors by increasing human presence within the affected areas. Many wildlife species, including the local mountain lion population (CC-N) which, as a candidate species, are afforded full protections under the California Endangered Species Acts, are sensitive to human noise and activity, and avoid areas that are frequented by humans.[29] For some species, this reduces the availability of suitable sites for denning, nesting and hunting or foraging. For example, e-bikes, which are increasingly common on open spaces trails, have been found to emit high frequency motor noise that is audible to bat species and may disrupt bat roosting behavior at sites within

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[25] Syphard, A. D., T. J. Brennan, and J. E. Keeley (2019). Extent and drivers of vegetation type conversion in Southern California chaparral. *Ecosphere* 10(7): e02796.10.1002/ecs2.2796. **Attached as Exhibit C.**

[26] Rundel, Philip. (2018). California Chaparral and Its Global Significance. In E. C. Underwood et al. (eds.), *Valuing Chaparral*, Springer Series on Environmental Management, https://doi.org/10.1007/978-3-319-68303-4_1 . **Attached as Exhibit D.**

[27] Cashen EA at 15-18.

[28] Cashen EA at 17-18, and Fig. 18.

[29] See e.g., San Francisco Estuary Institute (SFEI) (December 2021), E-Bikes and Open Space: The Current State of Research and Management Recommendations, at 8; available at https://www.sfei.org/documents/e-bikes-and-open-space-current-state-research-and-management-recommendations.

100-200 feet of bike trails.[30] Bats have been observed in Waterdog Open Space. As shown below, the unchecked expansion of new trails and shortcuts within the open space has already transformed formerly contiguous habitat areas into a growing spiderweb of trails.[31] Notably, most of these trails are parallel to other existing trails and thus superfluous as secondary connectors between previously established trails and trailheads. This includes sections of the Rambler trail, the Chaparral trail, and the Encinitas/Belmont Creek Trail. Taking action to decommission excessive parallel trails and shortcuts would significantly reduce the current negative impacts on native plants and wildlife habitat within the City's open space areas.

Fig. 2. Trail spidering near Canyon Creek Trail.

In addition, the City's sanctioning, through nonaction, of unauthorized trail construction and modifications implemented by private parties has included instances of tree, branch, and plant cuttings with discarded branches, plants and woody debris often being tossed into waterways where pathogens can infect other trees.[32] This careless behavior could increase the spread of *sudden oak death*, which has already been detected within Waterdog Lake Open Space and could devastate its vulnerable oak woodland habitat. In addition, spores of the fungus can attach to bicycle tires and be carried to new trails by unsuspecting riders.[33] The loss of this

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[30] *See e.g.*, H.T. Harvey & Associates (Sept. 17, 2021), Analysis of E-bike Noise and Recommendations for Buffer Distances between Bike Trails and Bat Roosts/Nesting Birds, at 13-14 (Prepared for Midpeninsula Regional Open Space District).

[31] Cashen EA, Figure 22. Habitat fragmentation caused by unauthorized trails and unnecessarily redundant trails in the southeast corner of Hidden Canyon Open Space.

[32] Cashen EA at 16.

[33] SFEI (2021), E-Bikes and Open Space, *supra* n. 25, at 10 (citing Davidson, J.M., and A.C. Wickland, et al. (2005), Transmission of *Phytophthora ramorum* in Mixed-Evergreen Forest in California. *Phytopathology* 95, 587–596. https://doi.org/10.1094/PHYTO-95-0587.

woodland habitat would impact numerous other species. Accordingly, both the unauthorized trails and their unauthorized construction pose threats to the biological integrity and biodiversity of this unique area.

2. Special Status Species

The term "special-status species" refers broadly to all plant and animal taxa that are tracked by the California Department of Fish and Wildlife's (CDFW) California Natural Diversity Database (CNDDB), regardless of their legal or protection status. Special status species fall into several categories; including species that are officially listed as threatened or endangered under the CESA or the ESA, species that are "Fully Protected" under California Fish and Game Code, and taxa considered by the CDFW to be Species of Special Concern, among others.[34]

At least four special status plant species that are considered to be rare or endangered throughout their range have been documented within Waterdog Lake Open Space This includes western leatherwood (*Dirca occidentalis*), Franciscan onion (*Allium peninsulare var. franciscanum)*, San Francisco collinsia *(Collinsia multicolor*), and arcuate bush-mallow (*Malacothamnus arcuatus*).[35] Several special-status animal species have also been observed within Waterdog Lake Open Space, including the following: [36]

- San Francisco dusky-footed woodrat (*Neotoma fuscipes annectens*) – California Species of Special Concern
- Cooper's hawk (*Accipiter cooperii*) – CDFW Watch List Species
- Sharp-shinned hawk (*Accipiter striatus*) – CDFW Watch List Species
- Merlin (*Falco columbarius*) – CDFW Watch List Species
- White-tailed kite (*Elanus leucurus*) – CDFW Fully Protected
- Northern harrier (*Circus hudsonius*) – California Species of Special Concern
- Oak titmouse (*Baeolophus inornatus*) – US Fish and Wildlife Service Bird of Conservation Concern
- Yellow warbler (*Setophaga petechia*) – California Species of Special Concern

In addition, several other species have the potential to occur in Waterdog area, including the San Francisco garter snake (*Thamnophis sirtalis tetrataenia*) and the California red-legged frog (*Rana draytonii*).[37]

According to the U.S. Fish & Wildlife Service (USFWS) online database, more than a dozen federally protected threatened and endangered species are known to occur within

[34] Cashen EA at 9.
[35] Cashen EA at 9-10; *see also* City of Belmont General Plan, Conservation element at 5-7.
[36] Cashen EA at 10-11; *see also* Cornell Lab of Ornithology, eBird (online database of bird sightings and species abundance and distribution), http://www.ebird.org (Last visited April 8, 2023).
[37] Cashen EA at 11.

Waterdog Lake Open Space, including the following:[38]

- Salt Marsh Harvest Mouse, Reithrodontomys raviventris
- California Least Tern, Sterna antillarum browni
- Marbled Murrelet, Brachyramphus marmoratus
- Green Sea Turtle, *Chelonia mydas*
- San Francisco Garter Snake, Thamnophis sirtalis tetrataenia
- California Red-legged frog, *Rana draytonii*
- Mission Blue Butterfly, Icaricia icarioides missionensis
- Monarch Butterfly, *Danaus plexippus*
- Fountain Thistle, Cirsium fontinale var. fontinale
- Marin Dwarf-flax, Hesperolinon congestum
- San Mateo Thornmint, Acanthomintha obovata ssp. duttonii
- San Mateo Woolly Sunflower, *Eriophyllum latilobum*
- White-rayed Pentachaeta, *Pentachaeta bellidiflora*

Fig. 3a and 3b. Mission Blue Butterflies observed at Waterdog Open Space.

Notably, our clients have documented Mission Blue Butterflies in Waterdog Open Space and observed them near stands of silver lupine, *lupinus albifrons*, one of their primary host plants, among other native plant species.[39] Specifically, Mission Blue Butterflies have been observed on the unauthorized "Soho trail" trail behind Soho Court. This trail cuts directly through the stand of silver lupine plants that provides essential habitat for these federally listed

[38] U.S. Fish and Wildlife Service (USFWS), IPaC Information for Planning and Consultation (online database), https://ipac.ecosphere.fws.gov/location/SZLHNGOIIFBIXP57VZBSRN4FGQ/resources (last visited April 10, 2023).
[39] Golden Gate National Parks Conservancy, "Mission Blue Butterfly," https://www.parksconservancy.org/conservation/mission-blue-butterfly (last visited June 12, 2023).

endangered butterflies.[40] This trail threatens butterfly habitat by fragmenting the meadow, disrupting soils, and creating a new pathway for invasive weeds that may outcompete with silver lupine. In addition, it appears that unauthorized trail builders have cut back mature lupine plants for the trail with no regard for the potential impacts this could have on these endangered butterflies. Most recently, the City has cut plants along the illegal trail behind Soho Court – including in the exact area where Mission Blue Butterflies have recently been observed. Such actions may well violate Section 9 of the federal ESA, which prohibits the unauthorized take of an endangered species.[41] The Soho trail needs to be closed immediately in order to protect the rare Mission Blue Butterflies that call Waterdog Open Space home.

As discussed above, unauthorized trails and trail construction threaten to further fragment and destabilize already sensitive natural communities, potentially eliminating already scarce plants and adversely impacting the wildlife and microorganisms that rely on them.

In addition, pallid bats, *Antrozous pallidus*, have been found in nearby areas within the City of Belmont. As noted above, bat species are particularly sensitive to high frequency noise, such as that emitted by e-bikes.[42] My clients have observed bats within and flying out of Waterdog Open space.

3. Mountain Lions

Mountain lions are a "specially protected mammal" in California, pursuant to the California Wildlife Protection Act (CWPA), enacted by Proposition 117 in 1990.[43] This law makes it "unlawful to possess, transport, import or sell any mountain lion or part or product thereof."[44] Proposition 117 also recognized that shrinking habitat is a significant threat to mountain lions and declared generally, as a matter of state priority, that habitat corridors "must be preserved to maintain the genetic integrity of California wildlife."[45]

Although mountain lions are not formally listed as threatened or endangered under CESA, CDFW is currently in the process of reviewing a proposal to list several regional subpopulations. Under CESA, species classified as a candidate species are afforded the same protections as listed species. As a result, mountain lions in the Central Coast Northern (CC-N) population are CESA-protected during the review period. This includes mountain lions within the San Francisco Peninsula, which is the northernmost segment of the CC-N population.

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[40] USFWS Environmental Conservation Online System, "Mission blue butterfly (*Icaricia icarioides missionensis*)." ECOS, https://ecos.fws.gov/ecp/species/6928 (last visited June 12, 2023).
[41] 16 U.S.C. § 1538 (B).
[42] See H.T. Harvey & Associates (Sept. 17, 2021), Analysis of E-bike Noise and Recommendations for Buffer Distances between Bike Trails and Bat Roosts/Nesting Birds, at 13. Midpeninsula Regional Open Space District (Project #4505-01); https://www.openspace.org/sites/default/files/E-bike_noise-analysis_09172021.pdf.
[43] Fish and Game Code § 4800.
[44] *Id*.; see also CDFW, "Mountain Lions in California," https://wildlife.ca.gov/Conservation/Mammals/Mountain-Lion#56231950-conservation-and-management (last visited April, 7, 2023).
[45] Fish and Game Code § 2780 (d).

One of the key issues discussed in the Mountain Lion Petition is the need for wildlife habitat corridors and highway crossing structures to reduce and prevent genetic isolation and vehicle strikes.[46] This is an increasingly important topic for local planning. The Ninth Circuit Court of Appeals has defined wildlife corridors as "avenues along which wide-ranging animals can travel, plants can propagate, genetic interchange can occur, populations can move in response to environmental changes and natural disasters, and threatened species can be replenished from other areas."[47] As noted previously, the Belmont General Plan also recognizes the value of open space in providing connective corridors for wildlife travel.[48]

Mountain lions have been reported in and near Waterdog Lake Open Space on several occasions.[49] In addition to reports in the news, Friends of Waterdog Open Space has documented mountain lion sightings reported on social media websites and compiled a map of these locations. (Attached as **Exhibit C**.) It is clear that mountain lions are using this area with some regularity. A lion's range can cover 20 to 60 square miles for a female, or more than 100 square miles for a male.

The presence of lions also means there is some potential for human-mountain lion conflicts. Effective planning can help alleviate these conflicts. In contrast, the proliferation of unauthorized trails into previously untrammeled parts of the open space may have the opposite effect, increasing human-mountain lion conflicts and deteriorating the area's value as a habitat corridor. Notably, the popularity of *night mountain biking* also poses special hazards for both cyclists and mountain lions. Because mountain lions are typically active at dusk and dawn,[50] conflicts are most likely during these times. In areas where mountain lions are known to occur, the CDFW specifically warns the public "*not* to hike, bike or jog alone, particularly around dawn, dusk or at night" when lions are more likely to be encountered.[51] Mountain biking thirty minutes before and after sunset is more likely to cause human-wildlife conflicts than daytime biking. It is unknown why the City of Belmont chose, after decades of posting the Open Space is only open from sunrise to sunset, to begin to encourage members of the public that the open space is open for use 30 minutes *before sunrise* and 30 minutes *after sunset.* This increases the risk of injury from a lion encounter or crash, which could lead to a lion being injured, hunted, or killed.[52] Additionally, this activity could disrupt and harass mountain lions and other animals like coyotes, especially if multiple mountain bikers are crashing through the woods during critical

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[46] Center for Biological Diversity, et al., Mountain Lion Petition, at 42, 52-53, 63, 71-72 (June 25, 2019), https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=171208&inline.
[47] See Marble Mountain Audubon Society v. Rice, 914 F.2d 179, 180 n. 2 (9th Cir.1990).
[48] *See* City of Belmont, 2035 General Plan, Policies 5.3-4 and 5.4-3 (2017).
[49] Stephen Ellison and Audrey Asisto, *'Aggressive' Mountain Lion Spotted in Belmont Neighborhood: Police*, NBC Bay Area (Jan. 19, 2022), https://www.nbcbayarea.com/news/local/aggressive-mountain-lion-spotted-in-belmont-neighborhood-police/2781735/.
[50] USDA Forest Service, Mountain Lions in the Central Sierra (Feb. 2020), https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd706878.pdf.
[51] CDFW, "Mountain Lions in California, https://wildlife.ca.gov/Conservation/Mammals/Mountain-Lion#562331251-how-do-i-live-and-recreate-safely-in-areas-with-mountain-lions (last visited April, 7, 2023).
[52] *Id.*

hunting and feeding times. This could also injure a lion, which is against the law.[53] The City's policy of allowing mountain bikers to ride trails prior to sunrise and after sunset places both bikers and lions (as well as other wildlife) at risk.

The loss of mountain lions in the area would be devastating – not only for the mountain lions, but for the loss of biodiversity that would impact the many other species that directly and indirectly rely on them. As top predators, mountain lions provide important ecological services that maintain ecosystem health and allow biodiversity to thrive.[54] A keystone species, mountain lions indirectly support plant recruitment in riparian areas, stabilize stream banks, and sustain healthy habitats for a myriad of aquatic and terrestrial species, including plants, invertebrates, fish, amphibians, reptiles, birds, and mammals.[55] Their kills are also an important source of food for multiple terrestrial and avian scavengers.[56]

In sum, the rich biodiversity of Waterdog Lake Open Space is a treasure for the community that must be protected. It is a sanctuary for multiple rare and endangered species and a vital wildlife corridor connecting the remnants of a once expansive biotic community. As such, its contribution to ecological diversity and the community's enjoyment thereof is invaluable.

B. Unauthorized trails damage watershed features and impair water quality.

The deteriorating condition of trails within Waterdog, together with the unauthorized construction, modification, and use of trails, is causing significant soil erosion that adversely impacts water quality. Unauthorized discharges of pollutants into waterways are prohibited by the state Porter Cologne Act and by the federal Clean Water Act. The city must comply with the Municipal Stormwater Permit to stay in compliance with these measures.[57]

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[53] Fish and Game Code § 4800.

[54] *See e.g.*, Ripple, W. J., & Beschta, R. L. (2006). Linking a cougar decline, trophic cascade, and catastrophic regime shift in Zion National Park. *Biological Conservation*, 133, 397–408; Ripple, W. J., & Beschta, R. L. (2008). Trophic cascades involving cougar, mule deer, and black oaks in Yosemite National Park. *Biological Conservation*, 141, 1249–1256; Ripple, W. J., J. A. Estes, et al. (2014). Status and ecological effects of the world 's largest carnivores. *Science*, 343(6167), 1241484; Ruth, T. K. & Elbroch, M. (2014). The carcass chronicles: carnivory, nutrient flow, and biodiversity. *Wild Felid Monitor*, 13-17; Barry, J. M., L. M. Elbroch, et al. (2019). Pumas as ecosystem engineers: ungulate carcasses support beetle assemblages in the Greater Yellowstone Ecosystem. *Oecologia*, 189(3), 577-586. Elbroch, L. M., & Quigley, H. (2019). Age-specific foraging strategies among pumas, and its implications for aiding ungulate populations through carnivore control. *Conservation Science and Practice*, 1(4), e23.

[55] *Id*.

[56] *Id*.

[57] California Regional Water Quality Control Board San Francisco Bay Region (SF Bay Regional Water Board), Municipal Regional Stormwater Permit, NPDES Permit No. CAS612008, Order No. R2-2022-0018, at 1-2. The City of Belmont and other municipalities within San Mateo County are subject to NPDES Permit No. CAS612008 issued by Order No. R2-2015-0049 on November 19, 2015, and amended by Order No. R2-2019-0004 on February 13, 2019, to discharge stormwater runoff from storm drains and watercourses within their jurisdictions.

Poorly designed and under-maintained trails are prone to excessive soil erosion that releases destabilized sediments into the airshed and watershed as pollutants. This is particularly evident in the wake of last winter's extreme rain events that washed out some trails, flushing unprecedented amounts of sediment into nearby culverts. A photo of the damage to culvert and stream along Canyon Creek trail is shown below.[58] The flow of sediments from new and existing trail damage also impacts Belmont Creek and Waterdog Lake, reducing the watershed's flood control capacity. Failure to prevent and decommission poorly designed trails has increased soil erosion – and the corresponding expense of dredging culverts and restoring damaged hillsides and stream crossings.

Fig. 3. Sedimentation of culvert in Hidden Canyon Open Space.

While riparian vegetation normally functions as a filter to capture sediments before they enter waterbodies, erosion near streambanks and creek crossings have no such filter. Instead,

[58] Cuviello, P. (Jan. 21, 2023), Photo of Hidden Canyon culvert sedimentation.

gullies and ruts can channel sediments directly into streams and rivers. Poorly placed trails and creek crossings can also cut into stream banks or cause them to collapse, dumping additional sediments directly into stream channels, while leaving destabilized banks susceptible to further wash-out and erosion during storm events that raise water levels.

Notably, sediment from trails and destabilized streambeds and banks impairs water quality and is recognized as a pollutant under state and federal law. Under the Municipal Regional Stormwater Permit, the City is required to "effectively prohibit the discharge of non-stormwater (materials other than stormwater) into storm drain systems and watercourses."[59] It is illegal "to discharge rubbish, refuse, bark, sawdust, or other solid wastes into surface waters or at any place where they would contact or where they would be eventually transported to surface waters, including flood plain areas." In addition, section 1602 of the Fish and Game Code prohibits unauthorized alteration of lake and streambeds.[60] While section 1610 of the Fish and Game Code makes exception for emergency projects that are "necessary to protect life or property," the City must still provide written notification of any emergency work within fourteen days to avert a violation.[61] This exception does not extend to non-emergency trail building that modifies stream beds.[62]

Here, there is no question that eroding and unauthorized trails within Waterdog and the adjacent areas have increased soil erosion and are impairing water quality. Failure to properly maintain trails has increased soil erosion. This is exacerbated by unauthorized use of hiking trails by bicycles, which tends to increase rutting and trail widening. Similarly, the proliferation of side trails and shortcuts to facilitate bike passage on narrow hiking trails disrupts vegetation and contributes to soil erosion.

The Cashen EA documented extreme erosion on many trails within the study area.[63] This included deeply rutted and damaged trail sections, and trails improperly cut into steep slopes that had become gullies. In some cases, more extreme trail widening has occurred in response to severe gullies making trail segments impassable. Cashen also observed numerous instances of increased trail density from unnecessary side trails, and an excessive numbers of creek crossings and "spidering" on trails around Belmont Creek. Many of the creek crossings are "wet crossings" that cut directly through streams, damaging stream banks and stream beds. Notably, Cashen found no hiking trails spared from the intrusion of bicycles, as every hiking trail examined showed signs of bicycle use, including bike encounters, tire ruts and tracks, and "technical features" like jumps and banked curves.

The seriousness of these issues is further corroborated by the recent *Draft Parks, Recreation, and Open Space Master Plan* (PROS Plan), which also identified significant erosion

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[59] SF Bay Regional Water Board, Municipal Regional Stormwater Permit, NPDES Permit No. CAS612008, Order No. R2-2022-0018, at 6.
[60] Fish and Game Code § 1602; *see also* Cashen EA at 8.
[61] Fish and Game Code § 1610 (a)(1) and (b).
[62] Fish and Game Code § 1610 (b).
[63] Cashen EA at 12-15.

problems on many open space trails, previously unmapped trails, potential impacts to sensitive species, and water quality concerns.[64] According to the Draft PROS Plan, 28% of the trails in Waterdog exhibit medium to high soil erosion, not counting creek crossings, and nearly 20% of trails are previously unmapped, user-created trails.[65] Despite acknowledging that "there are locations of 'high' erosion that should be addressed immediately," little if anything has been done to address these problems.[66]

The City cannot exempt its current management decisions from environmental review and accountability while it works on a new master plan. Specifically, the City has notices posted at the Open Space entrances and online outlining the closure of specific trails yet the City allows those trails to remain open allowing private individual to excavate and build new trails in recent weeks. Trail erosion and sedimentation of Waterdog Lake and Belmont Creek are longstanding and well-documented challenges requiring special permitting for expensive dredging to restore the watershed's functionality with respect to flood control.[67] Action to reduce erosion would also help control this sediment problem and reduce the frequency and cost of dredging.

C. Failure to maintain city property and comply with general plan goals.

The City's failure to properly maintain open space trails and prevent the proliferation of poorly designed and unauthorized trails has allowed these properties to deteriorate and accrue damages. This neglect also violates the agreements under which the City has obtained these properties to operate them for the public enjoyment of its citizens and conflicts with the City's general plan.

Waterdog Lake Open Space is situated on a tract of land that is leased by the City from Notre Dame de Namur University (NDNU). The City entered an initial 50-year lease in 1965 and renewed the lease in 2011.[68] The leased area consists of about 50 acres and includes Waterdog Lake, sections of Belmont Creek, Lake Road, trails, a sewer line, and open space. While the rental cost is a mere $100 per year, the value to the City in securing the Belmont Creek watershed, preserving the valley's rich biodiversity, and providing recreational and aesthetic enjoyment for its citizens is immense.

The Waterdog lease requires the City to maintain the area as a green belt, and to maintain, preserve, and operate the dam for flood control and for "recreational activities conducted and authorized by the City of Belmont." In addition, the agreement provides that the

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[64] City of Belmont, Draft Parks, Recreation, and Open Space Master Plan (PROS Plan), at 84-111, (June 2022).
[65] PROS Plan at 101, 106.
[66] PROS Plan at 108.
[67] *See, e.g.*, City of Belmont Parks and Recreation Commission, Staff Report: Belmont's Open Space Management Including Trails, Fire Management, Natural Resources, Boundary Management, and Interpretive Programs, at 6 (Dec. 7, 2016); Section 401 Water Quality Certification Public Notice: Belmont Creek Dredging (Sept. 2020), https://www.waterboards.ca.gov/sanfranciscobay/public_notices/401/BelmontCreek/index1.html
[68] City of Belmont City Council, Resolution Authorizing the Renewal of Lease with Notre Dame de Namur University for the Waterdog Lake Open Space Area (June 14, 2011).

"City shall, at its sole cost" maintain the dam and comply with all laws or regulations "pertaining to the maintenance and operation of the [dam and lake] and the use of the premises for recreational purposes."[69]

Similarly, the adjacent tract of open space land, known as the Brooks Preserve, was donated to the City by John Brooks on the condition that it be "maintained in perpetuity as an unspoiled wild area or 'green belt' to preserve the trees and natural environment."[70] However, contrary to this requirement, the Cashen EA found that construction of the Hillside and Marsh trails has eliminated trees and degraded the natural environment through adverse impacts to soils, hydrology, and habitat.[71] The area has not been maintained as an "unspoiled wild area."

As discussed above, the unauthorized construction and modification of trails has impaired water quality and natural resources that are protected by state and federal laws. The City has also failed to require open space users to comply with its own Parks and Recreation code, Chapter 16 of the Belmont City Code (BCC), which prohibits several problematic activities. For example, BCC section 16-24 makes it unlawful to discharge pollutants into waterways, but the City has not acted to deter unauthorized trails and creek crossings that discharge polluting sediments and tree cuttings into Waterdog Lake and Belmont Creek, and its tributaries.[72] BCC section 16-30 restricts motorized vehicle use to streets, but the City has not actively restricted the use of e-bikes on open space trails. And while BCC section 16-27 makes it unlawful to interfere with any person's lawful use of parks and open space so long as that use abides with applicable rules, the city has made no effort to prevent mountain bikers from interfering with those who seek to enjoy the proper use of hiking trails for hiking, walking, or running. Nor has the City worked to prevent mountain bikers from building unauthorized trails; instead, the City has rewarded this illegal behavior by management actions that allow these unauthorized trails to remain in use. As noted above, the use of bicycles on narrow single-track trails poses significant safety hazards for walkers, including elders and families with small children. It also interferes with enjoyment of low-impact recreational activities like wildlife viewing and birding.

The City has often publicly bragged about its reliance on volunteers, who are largely if not solely mountain bikers, to maintain and construct trails which has also contributed to resource damage.[73] These volunteers have created trail modifications that promote biking interests at the expense of other resource values. For example, the development of technical biking features like jumps, waterway crossings over steep falls without handrails, and banking curves on narrow hiking trails is inappropriate. Trail construction through riparian zones and wet

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[69] *Id.*; *see also*, City of Belmont City Council, Resolution No. 2722 (May 3, 1965).

[70] Cashen EA at 24 (citing: 29 Nov 1977 letter from HT Stearns, executor, to F Holland, Treasurer for the City of Belmont).

[71] Cashen EA at 16, 24.

[72] Some mountain bikers have published on social media sites that they regularly spray Roundup in the Open Space. Notably, some City officials also use this mountain biking social media site.

[73] *See,* City of Belmont, Parks and Recreation Commission Staff Report (Dec. 7, 2016), discussing partnerships with volunteer groups to relocate the Lake Loop Trail in 2015. According to the Cashen EA, the Lake Loop Trail should be permanently closed due to adverse impacts to wildlife, riparian habitat, and water quality. (Cashen EA at 25.)

areas has increased adverse impacts on sensitive riparian vegetation and wildlife and introduced non-native invasive plant species likely also violates Fish and Game Code section 1602. Trails near water features can create barriers for wildlife and may be prone to flooding and mud, which in turn encourages trail widening to avoid mud, resulting in greater disruption of vegetation and soil erosion. There are numerous trails that continue to cross seasonal waterways that are still functioning. Trails on steep hillsides are susceptible to gullying and severe soil erosion. In addition, trail enhancement by cutting trees or branches to improve clearance for bicycles has contributed to trail widening, which also disrupts vegetation and increases soil erosion. Improper disposal of woody debris has also impacted vegetation and waterways and increases risk of spreading *sudden oak death*. While the use of volunteer programs is attractive as a cost saving measure, training and supervision is necessary to ensure that trails are properly placed and designed using appropriate methods to prevent resource damage.

The City's failure to take action to maintain open space areas and prevent damage to their natural resources also conflicts with numerous provisions of the City's general plan, including these provisions of the Open Space Element and Conservation Element:

- Policy 4.4-1: "Continue to designate and protect open space lands for the preservation of scenic areas, natural drainage ways, and plant and wildlife habitats, for outdoor recreation, and for public health and safety."
- Policy 4.4-5 (Action 4.4-5a): "Ensure that the updated Parks, Recreation, and Open Space. Master Plan includes:
  - Identification and implementation strategies for trail maintenance and design standards for trails through open space lands.
  - Identification [of] trails that are no longer necessary or are causing resource damage such as erosion and implementation strategies to remove them."

- Policy 4.4-6: "Develop programs to control invasive plant species that threaten the natural resources."
- Policy 5.3-1: "Support the protection, preservation, restoration, and enhancement of habitats of State or federally listed rare, threatened, endangered and/or other sensitive and special status species, and favor enhancement of contiguous areas over small, segmented remainder parcels."
- Policy 5.3-2: "Continue to maintain, protect, restore, and enhance Belmont's ecologically important areas and seek to reduce impacts on them, including the creek corridors, the open space, and the wetlands around O'Neill Slough."
- Policy 5.3-4: "Maintain functional wildlife corridors and habitat linkage in order to contribute to regional biodiversity and the viability of rare, unique or sensitive biological resources throughout the city and region."
- Policy 5.3-5: "In design and construction, require use of best practices that preserve natural resources, such as soil, trees, native plants, and permeable surfaces."
- Policy 5.4-3: "Protect, restore, and enhance a continuous corridor of native riparian vegetation and wildlife habitat along Belmont's waterways, water bodies, and wetlands."

- Policy 5.4-4: "Preserve and enhance the natural riparian environment along waterway corridors, including Belmont Creek, by minimizing environmental and visual impacts."
- Policy 5.5-4: "Ensure that the design and construction of new infrastructure elements does not contribute to stream bank or hillside erosion or creek or wetland siltation, and incorporates site design and source control BMPs, construction phase BMPs, and treatment control BMPs to minimize impacts to water quality."

Failure to comply with general plan provisions further underscores the inconsistency of the City's continued sanctioning of unauthorized trails and uses with the City's express goals and policies. These policies stem from our community's process of identifying shared goals. The current pattern of neglected maintenance and unauthorized trails is unsustainable and conflicts with these goals, and will continue to damage city property and natural resources unless the City steps up and deals with these issues. For all of these reasons, remedial action is needed.

III. Failure to Comply with Applicable Law

The City's failure to maintain open space and prevent damage to city property and resources violates California's taxpayer waste law, discharges of pollutants into waterways in violation of the Porter Cologne Act[74] and the federal Clean Water Act (CWA),[75] and disrupts of sensitive habitat and species in violation of California Fish and Game Code section 1602, and may also violate the California Endangered Species Act (CESA),[76] and the federal Endangered Species Act (ESA).[77]

A. Damage to City property and wildlife resources violate the Taxpayer Waste Law.

California Code of Civil Procedure section 526a allows taxpayers to file actions against local government entities "to obtain a judgment, restraining and preventing any illegal expenditure of, waste of, or injury to, the estate, funds, or other property of a local agency."[78] Such an action may be maintained "either by a citizen resident therein, or by a corporation, who is assessed for and is liable to pay, or, within one year before the commencement of the action, has paid, a tax therein."[79]

The taxpayer waste law represents a legislative decision to create judicial access for parties that might otherwise lack standing to seek relief and hold government entities accountable for misuse of public funds and property.[80] Accordingly, a plaintiff must show

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[74] Water Code division 7, §§ 13000 *et seq.*
[75] 33 U.S.C. §§ 1251 *et seq.*
[76] Fish and Game Code §§ 2050 *et seq.*
[77] 16 U.S.C. §§ 1531 *et seq.*
[78] Cal. Code Civ. Proc. § 526a.
[79] *Id.*
[80] *McKinny v. Bd. of Trs.* (1982) 31 Cal. 3d 79, 91.

taxpayer or fee-payer status in connection to the entity being sued, but no showing of direct injury is required.[81] And, while the statute speaks of injunctive relief, courts have extended taxpayer standing to actions for declaratory relief, mandamus, and damages.[82]

Notably, "California courts have consistently construed section 526a liberally to achieve [its] remedial purpose."[83] While some expenditure of public funds must be at issue, "it is immaterial that the amount of the illegal expenditures is small or that the illegal procedures actually permit a saving of tax funds."[84] The nature of the required *expenditure* has also been broadly interpreted to include a wide variety of illegal or wasteful actions funded by the entity in question. For example, courts have held taxpayer suits to validly enjoin government actions to build unnecessary sewer lines,[85] to implement unjustifiably expensive school consolidation plans,[86] or to enjoin paid employees from carrying out actions later determined to be illegal.[87]

Notably, courts have also restricted the scope of taxpayer waste actions to actions or inactions involving violation of a mandatory duty. That is, the action won't lie for a mere disagreement with an entity's or official's discretionary action where this is properly exercised and within the scope of the actor's authority.[88] Nor will a taxpayer action be sustained where the government action is perfectly legal and in accordance with valid statutes and regulations.[89] However, a taxpayer "may state a cause of action under section 526a by alleging that funds are being expended for a project or program with no public benefit and no useful purpose, or for a plan costing much more than any alternative plans considered, without a finding of any additional public benefit."[90]

Here, the City's failure to prevent the deterioration of public trails, open space lands, watercourses, and other terrestrial and wildlife resources has directly damaged public property by destabilizing soils and unauthorized construction and modification of trails. This may also violate the terms and conditions of land donations and lease agreements that define the scope of the City's responsibilities for said lands. In addition, by allowing severe soils erosion to persist and worsen, the City's inaction has contributed to siltation of Waterdog Lake and Belmont Creek, incurring future expense of dredging and remedial flood control measures.

Further, by failing to decommission unauthorized and poorly defined trails and creek crossings that discharge sediments into Belmont Creek, the city has violated its municipal waste

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[81] *Blair v. Pitchess* (1971) 5 Cal. 3d 258, 268.
[82] *Van Atta v. Scott* (1980) 27 Cal. 3d 424, 449-450.
[83] *Blair v. Pitchess* (1971) 5 Cal. 3d 258, 268.
[84] *Blair v. Pitchess* (1971) 5 Cal. 3d 258, 268.
[85] *Ceres v. Modesto* (1969) 274 Cal. App. 2d 545, 554-55.
[86] Los Altos Property Owners Assn. v. Hutcheon (1977) 69 Cal. App. 3d 22, 26.
[87] *Blair v. Pitchess* (1971) 5 Cal. 3d 258, 269-70 (recounting cases where taxpayer waste applied to public employees issuing loyalty oaths or illegal wiretaps).
[88] Humane Soc'y of the United States v. State Bd. of Equalization (2007) 152 Cal. App. 4th 349, 358; see also Sundance v. Municipal Court (1986) 42 Cal.3d 1101, 1137–1139.
[89] Humane Soc'y of the United States v. State Bd. of Equalization (2007) 152 Cal. App. 4th 349, 361.
[90] *TRIM, Inc. v. Cty. of Monterey* (1978) 86 Cal. App. 3d 539, 543.

permit, which is a violation of the Porter Cologne Act and the Clean Water Act. In addition, by authorizing or allowing trails to damage and alter streambeds, the City has potentially violated Fish and Game Code section 1602. And, by authorizing or allowing trails the use of trails that disrupt and harm protected plants and wildlife species, the City is likely in violation of the CESA and ESA.

In addition, the City's failure to close unauthorized trails and implicit sanctioning of the construction and use of new trails without conducting any environmental review also violates the City's mandatory duty to comply with the CEQA.[91] As indicated above, new trails have numerous potentially significant effects on the environment and thus are not exempt from CEQA review. The City can choose to analyze these impacts through a programmatic level environmental analysis of the proposed PROS Plan,[92] or on a project-by-project basis, but it cannot legally ignore its duties under CEQA.

Thus, if any one or more of these violations wastes or injures public property, or violates a law or mandatory duty, members of Friends of Waterdog Open Space are within their rights as City residents and taxpayers to seek relief.

Notably, the City's authorization of unsupervised trail work by volunteers is not immune to a taxpayer waste claim. The City's reliance and publicly stated appreciation to mountain bikers for maintaining and building trails and close relationship to mountain bikers makes clear this is a City program; as such, if this is found to damage public property, or violate other laws, provide no public benefit, or serve no useful purpose, it remains well within the scope of a taxpayer waste claim, and city employees can be enjoined from administering the program. Furthermore, a municipality may not contract away its legislative and governmental functions and thereby escape responsibility for a municipal function, such as providing for the maintenance of open space areas.[93] Indeed, a contract that purports to abnegate public responsibility for a municipal function is invalid as contrary to public policy.[94]

B. Failure to control sediment pollution violates Water Code and Clean Water Act

Congress enacted the Clean Water Act ("CWA") "to restore and maintain the chemical,

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[91] CEQA requires local governments to conduct an environmental analysis of any projects that may have a significant effect on the environment. *See* Pub. Resources Code §§ 21000 *et seq*.
[92] *See* 14 Cal. Code Regs. § 15168. Notably, the City did not conduct a CEQA analysis prior to releasing its Draft PROS Plan in June 2022, claiming it was not a project. However, in Fall 2022 the City announced it would comply with CEQA after all and is now in the process of preparing an initial study to evaluate the scope of environmental analysis to be conducted; *see* https://belmontprosplan.com/our-plan.
[93] S*ee e.g., Morrison Homes Corp. v. City of Pleasanton* (1976) 58 Cal. App. 3d 724, 734. Indeed, a long line of California cases establishes that a government may not bargain away its right to exercise its police power in the future; *see e.g., Avco Community Developers, Inc. v. South Coast Regional Com.* (1976) 17 Cal.3d 785, 800; *Delucchi v. County of Santa Cruz* (1986) 179 Cal. App. 3d 814, 823.
[94] County Mobilehome Positive Action Com., Inc. v. County of San Diego (1998) 62 Cal.App.4th 727.

physical and biological integrity of the Nation's waters."[95] Under the Clean Water Act, it is the primary responsibility of states "to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources."[96]The federal CWA prohibits the unpermitted discharge of pollutants into navigable waters,[97] which generally includes navigable rivers, streams, lakes, and adjacent wetlands.[98] Courts have found that activities that disturb land or streambeds and cause release of natural sediments into waterways constitutes discharge of a pollutant because this impairs water quality.

The CWA also provides that "any citizen may commence a civil action" against a person or governmental agency that is alleged to be in violation of this act to compel compliance or seek civil penalties.[99] Such action may be commenced "sixty days after the plaintiff has given notice of the alleged violation (i) to the Administrator, (ii) to the State in which the alleged violation occurs, and (iii) to any alleged violator of the standard, limitation, or order."[100]

The State of California enacted the Porter-Cologne Act to protect the water quality by restricting the unauthorized pollution of the state's natural waters.[101] The Porter Cologne Act also requires permits to regulate activities that discharge pollutants into waterways. These requirements overlap with the federal CWA and provide a framework for the state's implementation of the CWA by administering permits and overseeing compliance at the state level. This includes implementation of section 402 of the CWA, known as the National Pollutant Discharge Elimination System (NPDES). State issued NPDES permits regulate pollution by establishing conditions for compliance with the CWA. Permits are issued and administered by Regional Water Quality Control Boards that are overseen by the State Water Resources Control Board.

Under the NPDES program, cities around the San Francisco Bay Region, including the City of Belmont, are covered by a general permit, the Municipal Regional Stormwater NPDES Permit for the San Francisco Bay Region (MRP).[102] This permit contains the following prohibitions:[103]

> A.1. The Permittees shall, within their respective jurisdictions, effectively prohibit the discharge of non-stormwater (materials other than stormwater) into storm drain systems and watercourses. NPDES-permitted discharges are exempt from this prohibition. Provision C.15 describes a tiered categorization of non-stormwater

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[95] 33 U.S.C. § 1251(a).
[96] 33 U.S.C. § 1251(b).
[97] 33 U.S.C. § 1311(a).
[98] 33 U.S.C. § 1362(7); 40 C.F.R. § 120.2 (amended by Revised Definition of "Waters of the United States," 88 Fed. Reg. 3004 (January 18, 2023) (effective date March 20, 2023)).
[99] 33 U.S.C. § 1365(a).
[100] 33 U.S.C. § 1365(b).
[101] Water Code division 7, §§ 13000 *et seq.*
[102] California Regional Water Quality Control Board, San Francisco Bay Region Municipal Regional Stormwater NPDES Permit (Hereinafter "MRP"), Order No. R2-2022-0018, NPDES Permit No. CAS612008 (May 11, 2022).
[103] MRP at 6.

> discharges based on potential for pollutant content that may be discharged upon adequate assurance that the discharge contains no pollutants of concern at concentrations that will impact beneficial uses or cause exceedances of water quality standards.
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> A.2. It shall be prohibited to discharge rubbish, refuse, bark, sawdust, or other solid wastes into surface waters or at any place where they would contact or where they would be eventually transported to surface waters, including flood plain areas. Permittees are also subject to the trash discharge prohibition in the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California and the Water Quality Control Plan for Ocean Waters of California.

The MRP also requires Bay Area cities to utilize "timely implementation of control measures" and "Best Management Practices" (BMPs) to minimize discharges of pollutants and maintain compliance with the CWA. Failure to report pollution discharges, and failure to implement control measures and BMPs are violations of the MRP. Failure to comply with NPDES permit conditions is a violation of the CWA and the Porter Cologne Act provisions under which the permit is issued.

Here, the City has allowed unauthorized trail construction, deteriorating trails, and poorly designed stream crossings to discharge sediments into Waterdog Lake and Belmont Creek. There is no indication that any timely control measures or BMPs have been implemented to prevent these pollution discharges, or that these discharges and streambed modifications have been reported to the Regional Water Quality Control Board. Accordingly, the City has violated the MRP and is therefore in violation of the CWA and the Porter Cologne Act.

C. Alteration of streambanks and streambeds violates the Fish and Game Code.

Section 1602 of the California Fish & Game Code encodes requirements of California's Lake and Streambed Alteration Program. Pursuant to Fish and Game Code section 1602, an entity must notify the CDFW prior to commencing any activity that will substantially divert or obstruct the natural flow, or substantially change or use any material from the bed, channel or bank of any river, stream, or lake.[104] This includes modification of stream channels and riparian vegetation that stabilizes streambanks.

Here, the proliferation of unauthorized and poorly designed stream crossings has damaged and destabilized streambanks and riparian vegetation at numerous points throughout the open space areas. Some of these bike crossings have also impaired or significantly altered sections of Belmont Creek's streambed. In addition, the removal of trees and riparian vegetation to construct and modify the Brooks Marsh trail has substantially altered a riparian area. Unless the City has notified CDFW and obtained prior authorization for these activities, such actions are

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[104] F&G Code § 1602.

violations of Fish & Game Code section 1602.

D. Authorizing or failing to prevent harm to protected species violates CESA, ESA, and provisions of the Fish and Game Code.

The federal ESA was enacted "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species."[105] It provides a method for identifying and listing species whose continued survival is threatened or endangered, and which therefore warrant special protections to ensure their conservation and recovery. The term "endangered species" means any species which is in danger of extinction throughout all or a significant portion of its range, while the term "threatened species" refers to any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.[106] Protective measures include procedures for consultation and permitting to restrict activities that could potentially kill, or *take*, one or more members of a listed species,[107] and procedures for the identification and protection of critical habitat.[108] Section 9 of the federal ESA expressly prohibits any unauthorized *take* of an endangered species.[109] Notably, the ESA defines the term "*take*" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."[110] In addition, the Act's implementing regulations further clarify that "*harass* . . . means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering."

Similarly, the State of California enacted the CESA to protect the state's biodiversity and provide for the conservation of threatened and endangered species in California.[111] Like the ESA, the CESA provides a process for the identification and listing of species and protective measure to ensure their protection and recovery. The two acts are similar in purpose but not identical, and species listed under one of the acts may or may not be listed under the other. As stated earlier, the local mountain lion population is protected under CESA. In addition, the local mountain lion population is also protected under the CWPA, which makes it unlawful "to take, injure, possess, transport, import or sell" mountain lions, and pelts or trophies.[112]

As discussed above, several protected species have been documented within Waterdog Lake Open Space and the adjacent areas, including species protected under the ESA and the CESA. The ongoing proliferation of trails through sensitive areas poses a significant threat to

[105] 16 U.S.C. § 1531.
[106] 16 U.S.C. § 1532 (6), (20).
[107] 16 U.S.C. §§ 1536, 1539.
[108] 16 U.S.C. § 1533.
[109] 16 U.S.C. § 1538 (B).
[110] 16 U.S.C. § 1532 (19).
[111] Fish and Game Code §§ 2050 *et seq.*
[112] Fish and Game Code § 4800 (b).

these species, through direct injury, take, or harassment of individuals, and through habitat destruction and fragmentation. The City's failure to protect species by closing unauthorized trails, enforcing trail use restrictions, and by implementing other protective measure violate provisions of the ESA, CESA, and CWPA.

In particular, the City is violating the ESA by allowing unauthorized trails to be cut through Silver Lupine stands, a key host plant for endangered Mission Blue Butterflies, without examining how this could disrupt the butterflies' behavior or reproduction or obtaining an Incidental Take Permit as required by law.[113] The City's failure to regulate or decommission unauthorized trails has also exposed the local CC-N population of Mountain Lions to increased risk of harassment and injury, and may also constitute or contribute to violations of the CESA and the CWPA.

The City's recent public announcement that it will not be able to close trails until after this summer raises additional concerns, given that the heaviest usage of the open space occurs during the summer months. It is not clear why constructing a fence will take this long – or why temporary barriers cannot be erected in the interim. Clearly, taking action to block hazardous and damaging trails, even if temporary, is warranted. If the City is unable to properly maintain and manage its open space trails, other curative actions are necessary.

IV. Demand for Remedial Action

To avoid litigation, the City must take action to address the above sited issues, including by closing or decommissioning all unauthorized trails, returning to decades-long sunrise to sunset open hours in order to allow wildlife the ability to forage and feed during these critical hours and enforce and adhere to existing laws and regulations. More specifically, the following actions are necessary to rectify this situation:

(1) The City must permanently close and restore the following trails:

- The Belmont Creek riparian trail in the Brooks Preserve (due to impacts on special-status species, riparian habitat and water quality, and because it violates the terms of the land donation).
- The Hillside trail behind Soho Court in the Brooks Preserve because Mission Blue Butterflies and their host plants have been observed and documented in this area; in addition, the trail has incompatible slopes, erosion, impacts on oak woodland habitat, and it violates the terms of the land donation.
- The segment of the Finch Trail that runs parallel to the Finch Bypass Trail (due to redundancy and impacts to mature woodland habitat).
- The eastern segment of the Rambler Trail (due to redundancy, proliferation of unauthorized spur trails, severity of damage to soils and vegetation, fragmentation of habitat, and impacts to riparian habitat bisected by the trail).

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[113] 16 U.S.C. § 1539.

- The Canyon Creek Trail (due to redundancy, direct impacts to riparian habitat, and stream degradation).
- The Lake Loop Trail (due to impacts on wildlife, and potential impacts to riparian habitat and water quality).
- All other unauthorized trails.

(2) The City must minimize the number of stream crossings to the maximum extent possible. Stream crossings that remain should be modified to reduce impacts on soils, water quality, and aquatic habitat. In addition, the City should devise a strategy for preventing trail users from bypassing the existing dry crossings (bridges).

(3) The City must implement measures to prevent additional impacts to special-status plants and animals that occur in the vicinity of trails. This will require focused surveys and data collection.

(4) The City must adhere to the conservation goals and policies established in the City's General Plan, including the Open Space Element, and the current Open Space Master Plan..

(5) The City must prepare and implement a trail management plan that includes strategies for:

- reducing soil loss and improving the sustainability of designated trails.
- routine monitoring to assess trail conditions (e.g., degradation) and the efficacy of resource protection measures.
- preventing further use and proliferation of unauthorized trails.
- closing inappropriate trails (i.e., unauthorized trails and unnecessarily redundant trails).
- restoring habitat on unauthorized trails and trails to be decommissioned.

(6) The California Oak Mortality Task Force has issued guidelines for minimizing the risk of spreading SOD. To minimize the ecological impacts of SOD, the City must require trail crews to adhere to the California Oak Mortality Task Force guidelines. Friends of Waterdog participated in the 2023 SOD Blitz and submitted samples from Waterdog.

(7) The City should implement an "Early Detection Rapid Response" framework for invasive plant management without the use of herbicides.

Please contact us if the City is willing to address these violations and to discuss possible resolution. If the City does not take timely action to correct these violations, however, we are prepared to pursue litigation in federal court. If we do not hear back from the City by August 22, 2023, we intend to seek injunctive and declaratory relief regarding these violations. As you are aware, my clients have a long history of seeking to work with the City to address these concerns. My clients ask that the City reciprocate this good faith effort by working collaboratively, transparently, and lawfully for the protection of our public Open Space.

If you have any questions or wish to discuss this matter, or feel this notice is in error, please contact me at jblome@greenfirelaw.com. Thank you for your prompt attention to this matter.

Sincerely,

Jessica L. Blome

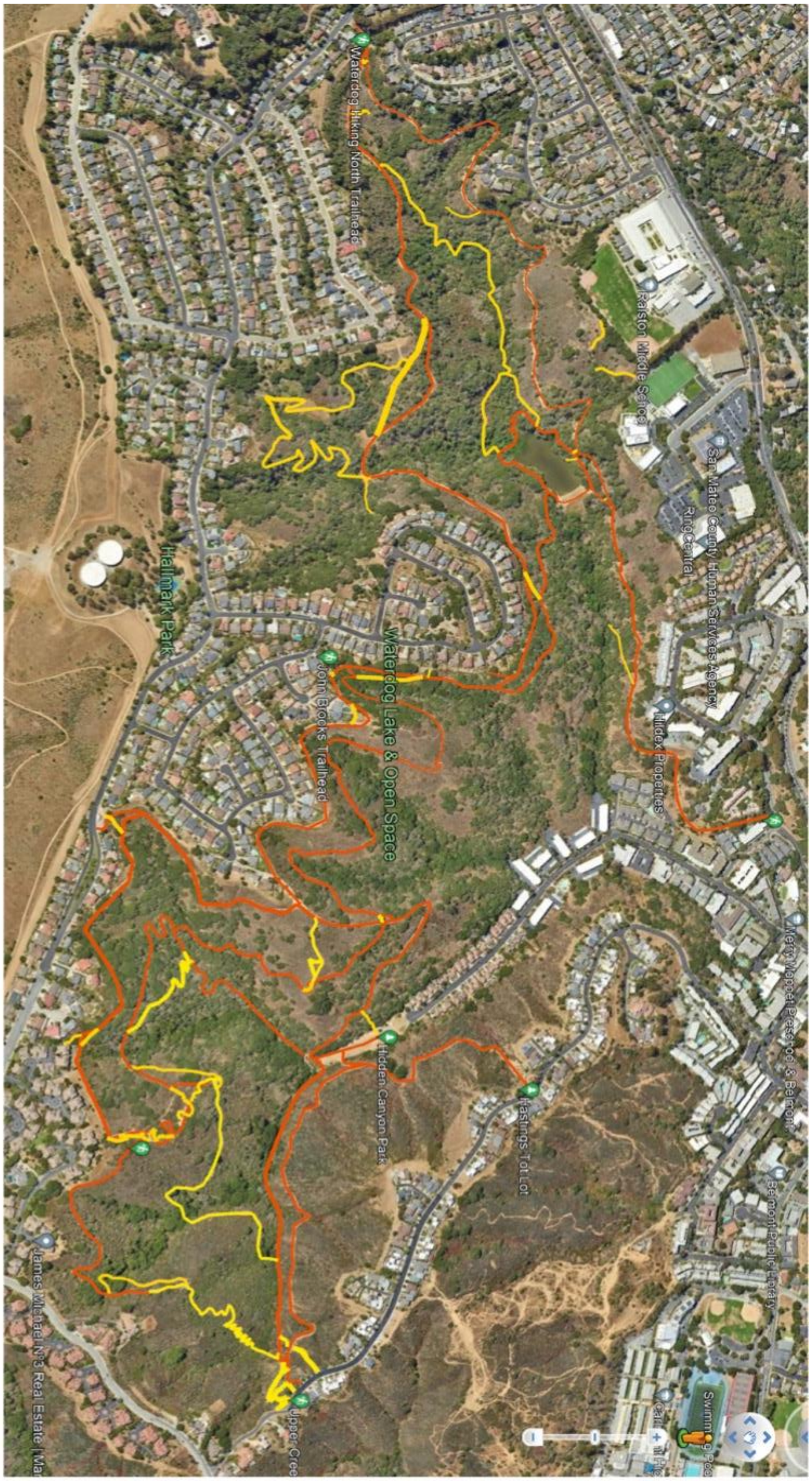
Jessica L. Blome
Susan Bradford
Greenfire Law, PC

Enclosures:

Exhibit A: Map of Waterdog Open Space Showing Existing Trails
Exhibit B: Cashen EA
Exhibit C: Syphard, et al. (2019), Extent and drivers of vegetation type conversion in Southern California chaparral.
Exhibit D: Rundel (2018). California Chaparral and Its Global Significance.

EXHIBIT A

Exhibit A:
Map of Waterdog Open Space Showing Existing Trails



**Red lines indicate established trails; Yellow lines indicate unauthorized trails*

EXHIBIT B

Scott Cashen, M.S.—Independent Biological Resources Consultant

March 29, 2021

Friends of Waterdog Open Space
FriendsofWaterDog@gmail.com

Subject: Environmental Assessment of Recreational Trails in John S. Brooks Memorial Open Space Preserve, Water Dog Lake Park, and Hidden Canyon Open Space

Dear Friends of Waterdog Open Space:

Per your request, I have completed an environmental assessment of recreational trails at the John S. Brooks Memorial Open Space Preserve, Water Dog Lake Park, and Hidden Canyon Open Space in the City of Belmont, California. The assessment identifies and discusses several environmental issues pertaining to soils, water quality, vegetation, and wildlife. I hope that the information provided in the assessment proves useful in your efforts to help the City develop a Parks, Recreation and Open Space Master Plan that is environmentally sustainable.

Sincerely,

Scott Cashen, M.S.
Senior Biologist

3264 Hudson Avenue, Walnut Creek, CA 94597

Environmental Assessment of Recreational Trails in John S. Brooks Memorial Open Space Preserve, Water Dog Lake Park, and Hidden Canyon Open Space

April 2021

Prepared for
Friends of Waterdog Open Space

Prepared by
Scott Cashen, M.S.
Senior Biologist

Overview

More than 225 species of birds, mammals, reptiles, and amphibians depend on California's riparian habitats, and California's oak woodlands have the richest wildlife species abundance of any habitat in the state. Yet these habitats are increasingly rare and are threatened by human activities. Conservation policies are essential to retaining the remaining examples of these diverse ecosystems.

This environmental assessment encompasses three properties: (1) the John S. Brooks Memorial Open Space Preserve, (2) Water Dog Lake Park, and (3) Hidden Canyon Open Space. These three properties (hereafter referred to as the "study area") comprise the majority (approximately 89%) of the open space and undeveloped park area in the City of Belmont. All three properties contain a network of interconnected trails that are open to the public for hiking, mountain biking, dog walking, and other non-motorized forms of recreation.

Most of the study area contains vegetation communities that are classified as "Sensitive Natural Communities" due to their relative rarity and threats to their persistence. The diverse habitats in the study area support a variety of plant and animal species. Four special-status plants, and eight special-status animals, have been documented in the study area. The Conservation Lands Network identifies most (approximately 91%) of the study area as "areas essential to conservation goals" for the San Francisco Bay Area.

Riparian habitat has been eliminated from 85% to 98% of its historic range in California (depending on bioregion). Riparian vegetation along Belmont Creek and Water Dog Lake represents some of the last riparian habitat remaining in the City. Riparian communities, and all aquatic features (including Water Dog Lake and streams) in the study area, are protected under federal and state regulations. The study area contains two types of oak woodlands (i.e., blue oak and coastal oak), both of which are classified as Sensitive Natural Communities.

The severity of ecological impacts caused by recreational activities is dependent on many factors, including the type of recreation (i.e., user group), intensity of use, trail design (i.e., a trail's siting and alignment relative to topography and soils), and trail density. Compared to hikers, mountain bikers can cause more soil damage and trail incision due to the "cutting" action of the bike's tires, especially when the tires slip (uphill slopes) or skid (downhill slopes). Trail degradation increases when mountain biking occurs on steep slopes, or on trails that fail to incorporate design standards to support such use.

Environmental impacts to soil, water, vegetation, and wildlife are almost always interrelated. Trails in the study area have experienced soil loss, which has been severe at some locations. The combination of water erosion and mechanical wear will cause additional soil loss due to improper trail design and type of use. Soil loss from trails can negatively impact vegetation, water quality, and habitat for aquatic organisms.

Riparian vegetation is critical to the quality of in-stream habitat and aids significantly in maintaining aquatic life by providing shade, food, and nutrients that form the basis of the food chain. The City's General Plan has policies to protect the scarce riparian resources that remain in the City. Contrary to these policies, the City allowed wet crossings and an unmapped trail to be constructed through the riparian community west of Water Dog Lake. Significant habitat loss occurred during trail construction. Ongoing use of the trail is causing additional habitat loss and degradation through trail widening, vegetation trampling and removal, and trail spidering, especially in the vicinity of Belmont Creek. The magnitude of impacts to riparian vegetation suggests a lack of environmental review and disregard for state regulations that protect riparian resources.

Vegetation has been cut to widen trails or increase vertical clearance for trail users, thereby altering microhabitat conditions necessary for two of the special-status plants found in the study area. Branches and other vegetative debris thrown into waterways (creeks) has altered habitat conditions, obstructed streamflow, and increased the risk of spreading the pathogen that causes Sudden Oak Death.

Some invasive species have become established in the study area. Invasive plants threaten biodiversity, alter ecosystem processes, and can cause extinction of native species. Vectors of invasive species include recreational trails, removal of the native overstory, and soil and vegetation disturbance. Most invasive plants are shade intolerant. Therefore, the best defense against invasive plants is maintenance of native plant cover.

Wildlife injuries or fatalities are more likely to occur due to collisions with bicycles because mountain bikers travel much faster than hikers. Reptiles, including the endangered San Francisco garter snake, are especially vulnerable to collisions with mountain bikes because reptiles often use open conditions created by trails for thermoregulation, and because they may not be capable of moving fast enough to avoid the collision.

Trail construction eliminates and fragments habitat for plants and animals. Poor trail design often leads to trail widening and unauthorized spur trails, which cause additional habitat loss. Research indicates mountain bikers increasingly create unauthorized trails because they seek more challenging, wider-ranging, or free-riding opportunities. There are numerous instances of trail widening and unauthorized trails in the study area.

The effects of trails on wildlife habitat extend considerable distances beyond the trails themselves. Many wildlife species are intolerant of humans and avoid using habitats near trails. Behavioral avoidance of habitat due to human activity is termed "functional habitat loss." The extent of functional habitat loss caused by recreational trails may extend several hundred meters. As a result, trail density is one of the main factors affecting wildlife in open space recreation areas. The greater the trail density, the fewer options there are for wildlife to use habitats away from trails. This is especially true in urbanized areas where the open space is essentially a habitat "island."

There are designated and undesignated trails throughout all portions of the study area, and several of the trails are redundant. This has resulted in an extremely high density of trails; almost all habitat in the study area is within 100 meters of a trail. The inability of wildlife to avoid human-related disturbance often results in negative behavioral or physiological reactions, which in turn affect reproductive and survival rates, and ultimately, persistence of wildlife populations. The high density of trails in the study area is undoubtedly having an effect on the natural environment and its function as wildlife habitat.

Many of the trails in the study area are causing excessive environmental degradation, are unsustainable, and do not conform to standards established in the Parks and Open Space Master Plan. In addition, two of the trails constructed in the Brooks Preserve violate the terms of the land donation. Recommendations are provided to rectify these issues.

CONTENTS

1. INTRODUCTION

This report contains my assessment of environmental impacts associated with recreational trails at the John S. Brooks Memorial Open Space Preserve, Water Dog Lake Park, and Hidden Canyon Open Space (hereafter referred to as the "study area") in the City of Belmont, California. I am an environmental biologist with 28 years of professional experience in wildlife biology, forestry, and natural resources management. My experience and scope of work in this regard has included evaluations of a wide range of biological resource issues, preparation and peer review of environmental compliance documents, and scientific field studies on various wildlife species and their habitats. My work in forestry has included layout and design of forest "skid trails," evaluations of forest health, and supervision of a study that assessed erosion control issues on logging roads throughout California. I have professional experience evaluating biological resource issues at other open space recreation areas, including those managed by the East Bay Regional Parks District and the Midpeninsula Regional Open Space District. My educational background includes a B.S. in Resource Management from the University of California at Berkeley, and a M.S. in Wildlife and Fisheries Science from the Pennsylvania State University.

The comments herein are based on my review of planning documents prepared by the City of Belmont ("City"), a review of scientific literature pertaining to recreational trails, two site visits, and the knowledge and experience I have acquired during my 28-year career in the field of natural resources management.

2. METHODS

The assessment of recreational trails in the study area included a review of the City's planning documents, including:

- The City's 2035 General Plan and associated Environmental Impact Report (2017).
- The Parks and Open Space Master Plan (1992).
- The Western Hills Area Plan (1990)
- Documents associated with the John S. Brooks Memorial Open Space Preserve (1977 and 1978).

In addition, the following documents were reviewed: (a) the California Natural Diversity Database ("CNDDB") and other scientific databases; (b) scientific literature pertaining to sensitive biological resources known to occur in the region; (c) topographic maps; (d) Google Earth imagery; (e) information and photographs posted at the Trailforks website and the Waterdog Trailkeepers Facebook page; and (f) trail user videos posted on YouTube.

Two site visits were conducted. On September 20, 2020, I visited the John S. Brooks Memorial Preserve ("Brooks Preserve") and Water Dog Lake Park. During the site visit I hiked: (a) portions of the John Brooks Trail; (b) portions of the Lake Road Trail; (c) portions of the Lake Loop Trail; (d) the Brooks hillside trail (located in the southern portion of the Brooks Preserve); and (e) the Brooks marsh trail (which extends from the John Brooks Trail to the eastern apex of the Lake Loop Trail).[1] On January 9, 2021, I visited Hidden Canyon Open Space. During the site visit I hiked: (a) the Canyon Creek Trail; (b) the Finch Trail; (c) the Ohlone Trail; (d) a portion of the Chaparral Trail; and (e) a portion of the Rambler Trail. The trails I hiked (and inspected) are depicted in Figure 1.

3. EXISTING ENVIRONMENT

The study area comprises the majority (approximately 89%) of the open space and undeveloped park area in the City of Belmont.[2] Lands in the study area are characterized by steeply sloping hillsides and canyons that are surrounded by residential development on the ridges above. The steep slopes (mostly between 30% and 45%) are susceptible to debris flows (landslides), slumping, and soil creep.[3] There are four major vegetation communities in the study area: Coastal Oak Woodland, Blue Oak Woodland, Valley Foothill Riparian, and Chamise-Redshank Chaparral.[4] In addition, there are several intermittent or ephemeral streams in the study area, the largest of which is Belmont Creek.[5] Belmont Creek flows through Water Dog Lake (a man-made reservoir) and eventually into San Francisco Bay.

The habitats in the study area support a variety of wildlife species. According to the Western Hills Area Plan: "[a]s a whole the area is a significant enclave of natural habitat for deer and other wildlife, the importance of which is increased due to the proximity to Water Dog Lake."[6] The Conservation Lands Network (a regional conservation strategy for the San Francisco Bay Area) identifies most (approximately 91%) of the study area as "areas essential to conservation goals."[7] According to the Conservation Lands Network: "[t]he lands in this category support high-value conservation targets and/or are adjacent to existing protected lands. These lands serve vital functions in any network configuration, and attaining the conservation goals will be difficult without them."[8] As described in the General Plan Conservation Element, the study area and nearby connected open spaces are valuable because they provide travel corridors for wildlife and increase wildlife population diversity. In addition, they play important roles in stormwater management, ecological functions, and other environmental conservation efforts.[9]

The City's General Plan contains numerous policies designed to protect open space lands and the associated natural resources. These policies include, but are not limited to:

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[1] The trail in the southern portion of the Brooks Preserve and the trail that extends from the John Brooks Trail to the eastern apex of the Lake Loop Trail are not named on the City's trails maps. Throughout this document they are referred to as the Brooks hillside trail and the Brooks marsh trail, respectively.
[2] General Plan, Parks, Recreation, and Open Space Element, Table 4-1.
[3] Western Hills Area Plan, pp. 4, 5, and 9.
[4] General Plan, Conservation Element, Figure 5-1.
[5] General Plan, Draft EIR, Figure 4.3-3.
[6] Western Hills Area Plan, p. 1.
[7] Conservation Lands Network. 2019. CLN Explorer 2.0 [interactive map]. Available at: <https://www.bayarealands.org/explorer-tool/>. (Accessed Feb 19, 2021).
[8] Bay Area Open Space Council. 2011. The Conservation Lands Network: San Francisco Bay Area Upland Habitat Goals Project Report. Berkeley, CA.
[9] General Plan, Conservation Element, p. 5-3.

Policy 4.4-1: "Continue to designate and protect open space lands for the preservation of scenic areas, natural drainage ways, and plant and wildlife habitats, for outdoor recreation, and for public health and safety."

Policy 4.4-5 (Action 4.4-5a): "Ensure that the updated Parks, Recreation, and Open Space Master Plan includes:

- Identification and implementation strategies for trail maintenance and design standards for trails through open space lands.
- Identification [of] trails that are no longer necessary or are causing resource damage such as erosion and implementation strategies to remove them."

Policy 4.4-6: "Develop programs to control invasive plant species that threaten the natural resources."

Policy 5.3-1: "Support the protection, preservation, restoration, and enhancement of habitats of State or federally listed rare, threatened, endangered and/or other sensitive and special status species, and favor enhancement of contiguous areas over small, segmented remainder parcels."

Policy 5.3-2: "Continue to maintain, protect, restore, and enhance Belmont's ecologically important areas and seek to reduce impacts on them, including the creek corridors, the open space, and the wetlands around O'Neill Slough."

Policy 5.3-4: "Maintain functional wildlife corridors and habitat linkage in order to contribute to regional biodiversity and the viability of rare, unique or sensitive biological resources throughout the city and region."

Policy 5.3-5: "In design and construction, require use of best practices that preserve natural resources, such as soil, trees, native plants, and permeable surfaces."

Policy 5.4-3: "Protect, restore, and enhance a continuous corridor of native riparian vegetation and wildlife habitat along Belmont's waterways, water bodies, and wetlands."

Policy 5.4-4: "Preserve and enhance the natural riparian environment along waterway corridors, including Belmont Creek, by minimizing environmental and visual impacts."

Policy 5.5-4: "Ensure that the design and construction of new infrastructure elements does not contribute to stream bank or hillside erosion or creek or wetland siltation, and incorporates site design and source control BMPs, construction phase BMPs, and treatment control BMPs to minimize impacts to water quality."

3.1. Sensitive Natural Communities

The State of California uses the National Vegetation Classification System's hierarchy of alliances and associations to classify vegetation communities. Each natural community is assigned a numerical rank from 1 (very rare and threatened) to 5 (demonstrably secure) depending on rarity and threat parameters.[10] Natural communities with a rank between 1 and 3 are considered "Sensitive Natural Communities."[11]

Oak woodlands have the richest wildlife species abundance of any habitat in California, with over 330 species of birds, mammals, reptiles, and amphibians depending on them at some stage in their life cycle.[12] The blue oak and coastal oak woodlands in the study area are considered Sensitive Natural Communities due to their relative rarity and threats to their persistence. Urbanization and agricultural development have eliminated approximately one-third of California's oak woodlands.[13] Of the oak woodlands that remain, only 40% are protected (e.g., in parks).[14] However, even those that are protected from development are susceptible to numerous threats. In many cases, existing oak woodlands are not regenerating naturally (i.e., young trees are not establishing to replace older trees as they senesce and die).[15] In addition, *Phytophthora ramorum*, the pathogen responsible for the plant disease known as Sudden Oak Death ("SOD"), started attacking California oaks in 1985 and became a full-scale epidemic by 1999.[16] Thus, Californians continue to lose their oak woodland heritage, even at sites that are protected from development.

More than 225 species of birds, mammals, reptiles, and amphibians depend on California's riparian habitats.[17] Most Valley Foothill Riparian and some Chamise-Redshank Chaparral communities are considered Sensitive Natural Communities (depending on the specific plants in the community). Classifying the study area's riparian and shrub communities to the level needed to determine rarity was beyond the scope of this report. At a minimum, the riparian communities in the study area are protected under section 1602 of California Fish and Game Code (Lake and Streambed Alteration Program). In addition, all aquatic features in the study area (irrespective of riparian vegetation) are protected under the federal Clean Water Act, the State's Porter-Cologne Water Quality Control Act, and section 1602 of California Fish and Game Code.

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[10] For a discussion of the system use to rank rarity of Natural Communities, *see*: <https://wildlife.ca.gov/Data/VegCAMP/Natural-Communities#sensitive%20natural%20communities>. For a list of Sensitive Natural Communities in California, *see*: <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=153609&inline>

[11] *Ibid.*

[12] CalPIF (California Partners in Flight). 2002. Version 2.0. The oak woodland bird conservation plan: a strategy for protecting and managing oak woodland habitats and associated birds in California (S. Zack, lead author). Point Reyes Bird Observatory, Stinson Beach, CA. p. 8.

[13] *Ibid.*

[14] *Ibid.*

[15] McCreary DD. 2009 (Rev). Regenerating Rangeland Oaks in California. University of California, Sierra Foothill Research and Extension Center. Available at: <https://anrcatalog.ucanr.edu/pdf/21601e.pdf>. *See also* California Wildlife Habitat Relationships System. 2005 [update]. Wildlife Habitats: Blue Oak Woodland. California Department of Fish and Game. California Interagency Wildlife Task Group. Available at: <https://www.wildlife.ca.gov/Data/CWHR/Wildlife-Habitats>.

[16] CalPIF (California Partners in Flight). 2002. Version 2.0. The oak woodland bird conservation plan: a strategy for protecting and managing oak woodland habitats and associated birds in California (S. Zack, lead author). Point Reyes Bird Observatory, Stinson Beach, CA.

[17] Riparian Habitat Joint Venture. 2004. Version 2.0. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight.

3.2. Special-Status Species

"Special-status species" is a broad term used to refer to all plant and animal taxa tracked by the California Department of Fish and Wildlife's ("CDFW") California Natural Diversity Database ("CNDDB"), regardless of their legal or protection status.[18] Special-status species fall into one or more of the following categories:

- Officially listed by the State of California or the Federal Government as Endangered, Threatened, or Rare.
- A candidate for state or federal listing as Endangered, Threatened, or Rare.
- Taxa which meet the criteria for listing, as described in Section 15380 of the California Environmental Quality Act ("CEQA"). All plants with a California Rare Plant Rank of 1 or 2 meet the criteria for listing. Some Rank 3 and 4 plants may satisfy the criteria for listing.
- Taxa considered by the California Department of Fish and Wildlife to be a Species of Special Concern.
- Species that are "Fully Protected" under California Fish and Game Code.
- Taxa designated as a special-status, sensitive, or declining species by other state or federal agencies, or a non-governmental organization, and determined by the CNDDB to be rare, restricted, declining, or threatened across their range in California. These include taxa listed in the California Native Plant Society's *Inventory of Rare and Endangered Plants of California*.
- Taxa that are biologically rare, very restricted in distribution, or declining throughout their range, but not currently threatened with extirpation.
- Population(s) in California that may be peripheral to the major portion of a taxon's range but are threatened with extirpation in California.
- Taxa closely associated with a habitat that is declining in California at a significant rate.

<u>Special-Status Plants</u>

Four special-status plant species have been documented in the study area: western leatherwood (*Dirca occidentalis*), Franciscan onion (*Allium peninsulare* var. *franciscanum*), San Francisco collinsia (*Collinsia multicolor*), and arcuate bush-mallow (*Malacothamnus arcuatus*).[19] All of these species have a Rare Plan Rank of 1B.2, which means they are rare or endangered throughout their range (in California and elsewhere).

Western leatherwood is a perennial deciduous shrub that occurs in various habitat types. The species has been documented at several locations in both Water Dog Lake Park and Hidden Canyon Open Space.[20] According to the CNDDB, western leatherwood populations at Water

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[18] For the lists of special-status plants and animals, *see*: <https://wildlife.ca.gov/Data/CNDDB/Plants-and-Animals>.
[19] California Natural Diversity Database (CNDDB). 2021. RareFind 5 [Internet]. California Department of Fish and Wildlife [Jan 31, 2021].
[20] *Ibid.*

Dog Lake Park and Hidden Canyon Open Space are threatened by trail construction and maintenance, and by competition with non-native plants.

Franciscan onion is a perennial bulbiferous herb that occurs in grasslands and woodlands. Franciscan onion is known to occur in both Water Dog Lake Park and Hidden Canyon Open Space. It has been documented along the Chaparral, Elevator, Ohlone, Berry, and Water Dog Lake trails.[21] According to the CNDDB, Franciscan onion populations at Water Dog Lake Park and Hidden Canyon Open Space are threatened by trail use and maintenance.

San Francisco collinsia is an annual herb associated with forests, woodlands, and coastal scrub. It has been documented in Water Dog Lake Park: "on bank and concrete spillway from Lake, as well as along trail."[22] According to the CNDDB, the population at Water Dog Lake Park is threatened by: "possible cleaning or extreme rain event could wash away plants from spillway."

Arcuate bush-mallow is a perennial evergreen shrub associated with chaparral and woodland habitats. The species was documented on a checklist of plants from Waterdog Lake-Hidden Canyon Park, but the precise location(s) of the plants was not recorded.

Special-Status Animals

The following special-status animal species have been detected in the study area:

- San Francisco dusky-footed woodrat (*Neotoma fuscipes annectens*) – California Species of Special Concern[23]
- Cooper's hawk (*Accipiter cooperii*) – CDFW Watch List Species[24]
- Sharp-shinned hawk (*Accipiter striatus*) – CDFW Watch List Species[25]
- Merlin (*Falco columbarius*) – CDFW Watch List Species[26]
- White-tailed kite (*Elanus leucurus*) – CDFW Fully Protected; BLM Sensitive Species[27]
- Northern harrier (*Circus hudsonius*) – California Species of Special Concern[28]
- Oak titmouse (*Baeolophus inornatus*) – US Fish and Wildlife Service Bird of Conservation Concern[29]
- Yellow warbler (*Setophaga petechia*) – California Species of Special Concern[30]

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[21] *Ibid.*
[22] *Ibid.*
[23] Belmont General Plan, p. 5-12. I detected woodrat middens in the study area during my site visits.
[24] eBird. 2021. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Available at: <http://www.ebird.org>. (Accessed Feb 19, 2021).
[25] *Ibid.*
[26] *Ibid.*
[27] *Ibid.*
[28] *Ibid.*
[29] *Ibid.*
[30] *Ibid.*

In addition, the following species have the potential to occur in the study area:[31]

- San Francisco garter snake (*Thamnophis sirtalis tetrataenia*) – federally and state listed as endangered
- California red-legged frog (*Rana draytonii*) –federally listed as threatened
- Western pond turtle (*Emys marmorata*) – California Species of Special Concern
- Pallid bat (*Antrozous pallidus*) – California Species of Special Concern
- Hoary bat (*Lasiurus cinereus*) – Western Bat Working Group "Medium Priority" species

3.3. City Adopted Trail Layout, Design, and Use Criteria

Standards for the layout, design, and use of trails in the study area were adopted by the City in its 1992 Parks and Open Space Master Plan ("Master Plan"). According to the Master Plan, multi-use trails are designed to accommodate hikers, mountain bikers, and equestrians.[32] They would be gravel-surfaced and 10 to 12 feet wide. Multi-use trails were generally proposed for higher elevation areas around the periphery of the study area. Maximum trail gradient would be 15%, and the trails would incorporate drainage improvements where necessary. In contrast, single-use trails would be narrow (2 to 4 feet wide) earthen paths open to hikers only.[33] Single-use trails were intended to provide a more secluded, natural hiking experience than the multi-use trails. The John Brooks Trail and Lake Road Trail were designed to be multi-use trails. All of the other trails I inspected were intended to serve as single-use (hiker-only) trails. During my site visits I observed mountain biking (or evidence thereof) on all of the trails, irrespective of the trail designations established in the Master Plan. Indeed, many of the hiker-only trails contain "technical trail features" that had been installed specifically for mountain bikers (Figure 2).[34]

In 1998 the City adopted a trail system map for the study area. The 1998 map depicted considerably more trails than portrayed in the 1992 Master Plan. This should have triggered supplemental environmental review; however, no additional environmental review was conducted. Moreover, some of the trails that were subsequently installed have different alignments than those depicted on the 1998 Open Space Trail System map. Most notably:

- The proposed route for the Brooks hillside trail was primarily along contour lines. However, much of the trail was constructed perpendicular to the slope (cross-contour), resulting in a trail that is characterized by steep slopes and several sloping turns where there are breaks in the grade.
- The proposed route for the Finch Trail was along the upper rim of the canyon at the southern edge of Hidden Canyon Open Space. However, the trail was constructed up the slope of the canyon approximately 400 feet north of the proposed route. The existing trail contains a series of switchbacks up the steepest section of the slope.

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[31] *See* Belmont General Plan, Conservation Element.
[32] Parks and Open Space Master Plan (1992), p. 45.
[33] *Ibid*.
[34] The term "technical trail features" refers to trail elements that enhance the character and difficulty of a trail. They include jumps, bridges, 'skinnies' (narrow items that can be traversed), and berms, among others.

- The Rambler Trail segment east of the Ohlone Trail was not depicted on the 1998 Open Space Trail System map (nor on the map provided in the 1992 Master Plan).

Although the 1998 Open Space Trail System map contained considerably more trails than depicted in the 1992 Master Plan, no changes were made to the trail use designations (i.e., single-use/hiker-only vs multi-use). However, all of the trails are currently being used for mountain biking, including the single-use trails that were approved for hiking use only.

4. ENVIRONMENTAL IMPACTS

It is widely accepted that recreational use of natural areas inevitably results in ecological impacts.[35] The severity of impacts on the natural environment is dependent on many factors, including the type of recreation (i.e., user group), number of recreationists, and the location of recreation activities in relation to sensitive resources or habitats. In addition, the overall impact of various user groups is dependent on trail design (i.e., a trail's siting and alignment relative to topography and soils) and intensity of use. Compared to hikers, mountain bikers can cause more soil damage and trail incision due to their faster velocity, and due to the "cutting" action of the bike's tires, especially when the tires slip (uphill slopes) or skid (downhill slopes).[36] Trail degradation is especially pronounced when mountain biking occurs on steep slopes. For example, White and others (2006) found that slope had a significant effect on mountain biking trail incision (soil loss).[37] As slope increased, maximum incision increased. In general, trail width also increased with trails on steeper slopes. Overall, the researchers concluded that mountain biking trail slopes greater than 12% had higher potential for degradation. This is consistent with my observations of the trails in the study area. Many of the degradation issues I observed are related to trails on steep slopes, and improper layout and design of those trails. The eastern segment of the Rambler Trail exemplifies the severity of degradation that can occur when mountain biking occurs on: (a) steep slopes, and (b) trails designed to standards adequate for hiking only (Figure 3). A similar progression of trail degradation can be anticipated on the newer Brooks Preserve trails over time. Quite simply, the hiker-only trails that are being used by mountain bikers fail to incorporate layout and design standards compatible with mountain biking use and resource conservation.

To facilitate discussion, the subsequent assessment of environmental impacts is divided into four general categories: impacts to soil, water, vegetation, and wildlife. However, in ecological systems these impacts are almost always interrelated. For example, impacts to soil often affects

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[35] D'Antonio A. 2020. Non-consumptive recreation and wildlife conservation: coexistence through collaboration. California Fish and Wildlife, Recreation Special Issue 9-10.

[36] Davies C, Newsome D. 2009. Mountain bike activity in natural areas: impacts, assessment and implications for management—a case study from John Forrest National Park, Western Australia. CRC for Sustainable Tourism Pty, Australia. *See also* White DD, Waskey MT, Brodehl GP, Foti PE. 2006. A Comparative Study of Impacts to Mountain Bike Trails in Five Common Ecological Regions of the Southwestern U.S. Journal of Park and Recreation Administration 24(2):21-41. *See also* Evju M, Hagen D, Jokerud M, Olsen SL, Selvaag SK, Vistad OI. 2021. Effects of mountain biking versus hiking on trails under different environmental conditions. Journal of Environmental Management 278(2):111554.

[37] White DD, Waskey MT, Brodehl GP, Foti PE. 2006. A Comparative Study of Impacts to Mountain Bike Trails in Five Common Ecological Regions of the Southwestern U.S. Journal of Park and Recreation Administration 24(2):21-41.

hydrology and water quality, which can impact habitat for aquatic plants and wildlife. Therefore, the impacts should not be viewed in isolation, but rather as components of the overall impact to the ecosystem.

4.1. Soil Issues

Many of the trails in the study area are incised and exhibit signs of soil loss (Figures 4 and 5). Improper trail usage and design can degrade soil conditions and cause erosion. From a conservation perspective, the loss of soil is perhaps the most significant form of environmental impact because it is long-term or irreversible without substantial management action, and eroded soil can enter waterways, causing secondary impacts to aquatic environments.[38]

Trail grade and slope alignment angle have the greatest influence on soil loss from recreational trails.[39] Numerous studies have shown that soil erosion rates become exponentially greater with increasing trail grades.[40] These findings can be explained by the greater velocity and erosivity of running water on steep slopes, and by increased slippage or gouging of feet and wheels that displace soil down-hill. The maximum sustainable grade of a trail is dependent on how the trail is used (e.g., hiking vs mountain biking), the amount and level of trail use, precipitation volume and intensity, soil type and durability, and the trail's design standards. However, as a general rule, the International Mountain Bicycling Association (2007) recommends that: (a) trail grades should never exceed 15%, and (b) the maximum sustainable grade should be 5% for sandy/fragile soils, and 10% for loamy soils or soils with mixed textures.[41] These recommendations are consistent with research that has shown substantially increased soil loss on trails with grades above approximately 10%.[42]

A trail's "slope alignment angle" is the angle between the prevailing landform slope and the trail's alignment. A trail aligned directly up and down the slope has an alignment angle of 0°, whereas a trail aligned directly across the slope has an alignment angle of 90°. The effects of a trail's slope alignment angle on soil loss is as influential as trail grade, because as the slope

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[38] Marion JL, Wimpey J. 2017. Assessing the influence of sustainable trail design and maintenance on soil loss. Journal of Environmental Management 189:46-57.
[39] *Ibid.*
[40] Dissmeyer GE, Foster GR. 1984. A guide for predicting sheet and rill erosion on forest land. USDA Forest Service Technical Publication R8 TP 6, 40 pp. *See also* Marion JL, Wimpey J. 2017. Assessing the influence of sustainable trail design and maintenance on soil loss. Journal of Environmental Management 189:46-57. *See also* Olive ND, Marion JL. 2009. The Influence of use-related, environmental and managerial factors on soil loss from recreational trails. Journal of Environmental Management 90:1483-1493. *See also* White DD, Waskey MT, Brodehl GP, Foti PE. 2006. A Comparative Study of Impacts to Mountain Bike Trails in Five Common Ecological Regions of the Southwestern U.S. Journal of Park and Recreation Administration 24(2):21-41.
[41] International Mountain Bike Association. 2007. In: Webber P. (Ed.). Managing Mountain Biking: IMBA's Guide to Providing Great Riding. The International Mountain Bike Association, Boulder, CO.
[42] Dissmeyer GE, Foster GR. 1984. A guide for predicting sheet and rill erosion on forest land. USDA Forest Service Technical Publication R8 TP 6, 40 pp. *See also* Marion JL, Wimpey J. 2017. Assessing the influence of sustainable trail design and maintenance on soil loss. Journal of Environmental Management 189:46-57. *See also* Olive ND, Marion JL. 2009. The Influence of use-related, environmental and managerial factors on soil loss from recreational trails. Journal of Environmental Management 90:1483-1493. *See also* White DD, Waskey MT, Brodehl GP, Foti PE. 2006. A Comparative Study of Impacts to Mountain Bike Trails in Five Common Ecological Regions of the Southwestern U.S. Journal of Park and Recreation Administration 24(2):21-41.

alignment angle decreases (i.e., becomes congruent with the slope), it becomes inherently more difficult to drain water off the trail.[43] Marion and Wimpey (2017) examined the relationship between soil loss and slope alignment angle and found a significant difference between the amount of soil loss on trails with a slope alignment angle less than 23° compared to those with alignment angles over 23°.[44] Soil loss was especially severe on trails that had both a slope alignment angle less than 23° and a grade above 16%.

Contrary to trail design guidelines issued by various organizations (e.g., the International Mountain Bicycling Association), many of the trails in the study area were constructed on steep slopes, have a slope alignment angle less than 23°, or both. For example, the average grade of the Chaparral and Brooks hillside trails is approximately 30%, with some segments having a grade of approximately 40%. Both of these trails have relatively long segments with slope alignment angles near 0° (i.e., they are aligned directly up and down the slope).

All of the trails I examined were incised, contained rills and gullies, and exhibited other signs of soil loss (Figures 6 and 7). For example, the eastern portion of the Rambler Trail has experienced severe erosion and has numerous, very large gullies. Portions of the Brooks hillside trail are deeply incised, especially where the trail contains descending turns and other technical trail features for mountain bikers. Although soil loss is especially evident on trail segments aligned perpendicular to the slope, segments that were constructed along contours (i.e., across the slope) have not been immune to soil loss. For example, trail widening, in conjunction with the installation of retaining walls, provided evidence of unstable soil conditions along the Finch and Ohlone trails.

When the trail bed is lower than the adjacent terrain, surface runoff is forced to flow down the trail and the trail effectively functions as a ditch. The combination of water erosion and mechanical wear quickly incises the trail bed. Tire ruts in the trail bed provide evidence that mountain bikes are contributing to the incision of trails in the study area (Figure 8), although the issue appears to be exacerbated by improper trail design (e.g., trail segments that are parallel to the direction of sheet flow). Soil loss issues in the study area will continue to worsen over time unless remedial actions are taken. I observed a few locations along the Canyon Creek Trail and trails in the Brooks Preserve where trail damage was facilitating sediment movement into an adjacent watercourse (Figure 9).

4.2. Water Issues

Erosion from trails can negatively impact water quality and habitat for aquatic organisms. In addition, watercourse crossings can have direct effects on aquatic organisms and their habitat. Wet crossings (i.e., trail crossing without a bridge that spans the watercourse) in particular increase the potential for: (a) crushing of aquatic plants and animals, (b) adverse modifications to stream geomorphology (e.g., degradation of the streambank), and (c) sediment transfer into and within the stream.

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[43] Marion JL, Wimpey J. 2017. Assessing the influence of sustainable trail design and maintenance on soil loss. Journal of Environmental Management 189:46-57.
[44] *Ibid.*

There are multiple wet crossings in the study area. I observed several issues at these crossings:

- Trail incision and mechanical wear of the trail substrate, resulting in sediment transfer into the creek (Figure 10).
- Trail shortcuts, resulting in unnecessary (extra) creek crossings (Figure 11).
- Some trails had improvised trail crossings (i.e., boards spanning the creek). However, there was evidence that bicyclists were bypassing some of the crossings and instead were riding directly through the creek (Figure 12).

It is unclear if the trail crossings received the appropriate environmental review to ensure compliance with the federal Clean Water Act and the State's Porter-Cologne Water Quality Control Act. At a minimum, removal of riparian vegetation to construct and maintain the Brooks marsh trail does not comply with section 1602 of California Fish and Game Code unless the City obtained authorization from the California Department of Fish and Wildlife.

4.3. Vegetation Issues

Impacts to Riparian Resources

Riparian ecosystems harbor the most diverse bird, amphibian, and reptile communities in the arid and semiarid portions of the western United States.[45] Riparian vegetation is critical to the quality of in-stream habitat and aids significantly in maintaining aquatic life by providing shade, food, and nutrients that form the basis of the food chain.[46] California's riparian habitat provides important breeding and over wintering grounds, migration stopover areas, and corridors for dispersal.[47] DeSante and George (1994) concluded that the loss of riparian habitats may be the most important cause of population decline among landbird species in western North America.[48] The National Research Council (2002) concluded that riparian areas perform a disproportionate number of biological and physical functions on a unit area basis and that the restoration of riparian function along America's waterbodies should be a national goal.[49]

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[45] Riparian Habitat Joint Venture. 2004. Version 2.0. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight. *See also* Abell DL (Technical Coordinator). 1989. Proceedings of the California Riparian Systems Conference: protection, management, and restoration for the 1990s; 1988 September 22-24; Davis, CA. Gen. Tech. Rep. PSW-110. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture.

[46] Jensen D, Torn S, Harte J. 1993. In our hands: a strategy for conserving California's biological diversity. University of California Press. Berkeley, CA.

[47] Riparian Habitat Joint Venture. 2004. Version 2.0. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight.

[48] DeSante DF, George TL. 1994. Population trends in the landbirds of western North America. Pages 173-190 in: JR Jehl Jr. and NK Johnson (eds.). A century of avifaunal change in western North America. Studies in Avian Biology No. 15. The Cooper Ornithological Society, Lawrence, KS.

[49] National Research Council 2002. Riparian Areas: Functions and Strategies for Management. Washington, DC: The National Academies Press.

The only riparian resources that remain in the City are located near Laurelwood Park, and in the study area along Water Dog Lake and Belmont Creek.[50] The City's General Plan has several policies to protect these riparian resources:

- Policy 5.4-3: "Protect, restore, and enhance a continuous corridor of native riparian vegetation and wildlife habitat along Belmont's waterways, water bodies, and wetlands."
- Policy 5.4-4: "Preserve and enhance the natural riparian environment along waterway corridors, including Belmont Creek, by minimizing environmental and visual impacts."
- Policy 5.5-4: "Ensure that the design and construction of new infrastructure elements does not contribute to stream bank or hillside erosion or creek or wetland siltation, and incorporates site design and source control BMPs, construction phase BMPs, and treatment control BMPs to minimize impacts to water quality."

The Master Plan recognized the importance and sensitivity of riparian (or "marsh") vegetation and thus recommended the City: (a) develop a nature study area to take advantage of natural marsh at the west end of the lake; (b) develop boardwalk access across portions of the marsh; and (c) implement a marsh vegetation management and enhancement program, possibly in conjunction with the schools.[51] Contrary to these recommendations and the City's General Plan policies, the Brooks marsh trail was constructed through the riparian vegetation community west of Water Dog Lake (Figure 13). In addition to habitat loss that occurred during trail construction, I observed evidence that ongoing use of the trail is causing additional habitat loss and degradation through: (a) trail widening (some of which appears to be intentional); (b) vegetation trampling and removal; (c) trail spidering, especially in the vicinity of Belmont Creek; and (d) the wet crossings at Belmont Creek (Figures 14).

<u>Debris Disposal</u>

There are numerous locations where vegetation had been cut to widen the trail or increase vertical clearance for trail users (Figure 15). A relatively large tree in the riparian area along the Brooks marsh trail had been felled (Figure 16). At many locations, branches and other vegetative debris had been indiscriminately thrown on top of vegetation adjacent to the trail, potentially impacting special-status plants that had been documented in the area. In some instances, the debris had been thrown into adjacent waterways (creeks), which has altered habitat conditions and may obstruct streamflow (Figure 17).

Phytophthora ramorum (the pathogen responsible for SOD) has been detected in Water Dog Lake Park.[52] *P. ramorum* prefers moist environments. One of the primary mechanisms for movement and spread of *P. ramorum* is through infested waterways.[53] As a result, throwing vegetative debris into waterways increases the risk of spreading SOD.

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[50] General Plan, Conservation Element, Figure 5-1.
[51] Parks and Open Space Master Plan (1992), p. 44.
[52] County of San Mateo, Agriculture / Weights and Measures. 2021. Sudden Oak Death (SOD) - *Phytophthora ramorum* [web page]. Available at: <https://agwm.smcgov.org/sudden-oak-death-sod-phytophthora-ramorum>. (Accessed Feb 19, 2021).
[53] California Oak Mortality Task Force. 2014. Sudden Oak Death Guidelines for Arborists. 6 pp. Available at: <http://www.suddenoakdeath.org/>. (Accessed Feb 19, 2021).

Microhabitat Conditions

Two of the special-status plants that occur in the study area (western leatherwood and San Francisco collinsia) are associated with shady, moist habitats.[54] Trail construction activities have removed plants from the overstory, thereby degrading microhabitat conditions for western leatherwood and San Francisco collinsia. My site visits did not coincide with the blooming periods of timing of western leatherwood and San Francisco collinsia. As a result, I was unable to assess the extent of impacts to these two species.

Invasive Plants

Invasive plants threaten biodiversity, alter ecosystem processes,[55] and can cause extinction of native species.[56] Indeed, next to habitat loss, invasive species pose the greatest threat to the nation's biodiversity and natural resources.[57] The City has recognized the threat invasive plants pose to biodiversity and wildfire safety.[58] Accordingly, policy 4.4-6 in the General Plan is to: "[d]evelop programs to control invasive plant species that threaten the natural resources."

Three things are required for an invasive plant to become established in an area:

1. A vector for transporting the plant or its propagules from one place to another. Recreational trails are vectors for invasive plants because trail users can transport invasive plant seeds via clothing, boots, and gear (e.g., bike tires).
2. Suitable conditions for invasive plant colonization. Soil and vegetation disturbance associated with trails creates suitable conditions for the establishment of invasive plants. Most invasive plants are shade intolerant.[59] Therefore, the best defense against invasive plants is maintenance of native plant cover.
3. A suitable environment for the invasive plant to survive, reproduce, and spread. Many invasive species possess a competitive advantage over native species. As a result,

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[54] California Native Plant Society, Rare Plant Program. 2021. Inventory of Rare and Endangered Plants of California (online edition, v8-03 0.39). Available at: <http://www.rareplants.cnps.org>. (Accessed 20 Feb 2021). *See also* Jepson Flora Project (eds.) 2021. Jepson eFlora. Available at: <https://ucjeps.berkeley.edu/eflora/>. (Accessed 20 Feb 2021).

[55] Vitousek P. 1990. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. Oikos 57:7–13. *See also* Theoharides KA, Dukes JS. 2007. Plant invasion across space and time: factors affecting nonindigenous species success during four stages of invasion. New Phytologist 176:256-273.

[56] Gurevitch J, Padilla DK. 2004. Are invasive species a major cause of extinctions? Trends in Ecology and Evolution 19(9):470-474.

[57] U.S. Department of the Interior, Office of Congressional and Legislative Affairs. 2013. Invasive Species Management. Statement for the Record: U.S. Department of the Interior Before the House Natural Resources Subcommittee on Public Lands and Environmental Regulation's oversight hearing on "Invasive Species Management on Federal Lands."

[58] *For example, see* City of Belmont. 2012 Nov 7. Staff Report from the Parks and Recreation Commission regarding discussion of Belmont's Open Space including current condition, management, and future planning.

[59] Keeley JE, Franklin J, D'Antonio C. 2011. Fire and Invasive Plants on California Landscapes. Chapter 8 *in* D. McKenzie et al. (eds.). The Landscape Ecology of Fire, Ecological Studies 213. Springer Science+Business Media B.V. *See also* Harper KA, Macdonald SE, Burton PJ, et al. 2005. Edge influences on forest structure and composition in fragmented landscapes. Conservation Biology 19(3):768-782.

invasive species can reproduce and spread exponentially, especially if the ecosystem lacks a mechanism for keeping them in check.[60] Vegetation communities in the study area are known to be susceptible to invasion; some invasive species (e.g., pampas grass and various broom species, among others) have already become established in the study area (Figure 18).

Multi-use trails may have more invasive species cover than single-use trails because they involve multiple user groups, and each user group can distribute invasive plant seeds in unique ways. Esby (2011) examined native and non-native plant distribution along hiker-only and multi-use trails in the Santa Monica Mountains National Recreation Area. Multi-use trails exhibited a significantly higher proportion of exotic (invasive) species than hiker-only trails.[61] These findings led the researcher to suggest that multi-use trails should be concentrated in: (a) a small portion of the recreation area, and (b) in vegetation communities less prone to exotic species invasion.

4.4. Impacts on Wildlife

Recreational trail users can directly cause mortality of plants and animals due to trampling and collisions with bicycles. Although trampling by hikers can occur, wildlife injuries or fatalities are more likely to occur due to collisions with bicycles because mountain bikers travel much faster than hikers. Reptiles are especially vulnerable to collisions with mountain bikes because reptiles often use open conditions created by trails for thermoregulation, and because they may not be capable of moving fast enough to avoid the collision (especially snakes).[62] There are records of San Francisco garter snakes being killed due to collisions with mountain bikes.[63] The San Francisco garter snake occurs in aquatic habitats (e.g., marshes, ponds, slow-moving streams) and adjacent upland areas.[64] As a result, mountain bike activity in the vicinity of Water Dog Lake and Belmont Creek pose a threat to this species .

Although recreational activities can directly cause mortality of wildlife, the majority of impacts occur due to anthropogenic (human caused) disturbance. Anthropogenic disturbance affects wildlife in ways comparable to predation, including: (a) increased vigilance, fleeing behavior, and energy expenditure; (b) reduced time at essential brooding, sheltering, and resource acquisition activities; and (c) changes in habitat selection.[65] Although these effects usually occur

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[60] California Department of Food and Agriculture, California Invasive Weed Awareness Coalition. 2005. California Noxious & Invasive Weed Action Plan. California Dept. of Food and Agriculture, Sacramento, CA.
[61] Esby EMS. 2011. Edge effects: Native and non-native plant distribution along single use and multi-use trails in the Santa Monica Mountains National Recreation Area, California. Montana State University: Bozeman, MT.
[62] Rochester CJ, Hathaway SA, Brown C, Pease K, Fisher R. 2001. Herpetofaunal monitoring in MSCP region of San Diego. U.S. Geological Survey, San Diego, CA. *See also* Miller A, Alvarez JA. 2016. Habitat Use and Management Considerations for the Threatened Alameda Whipsnake (*Masticophis lateralis euryxanthus*) in Central California. Western Wildlife 3:29–32.
[63] California Natural Diversity Database (CNDDB). 2021. RareFind 5 [Internet]. California Department of Fish and Wildlife [Jan 31, 2021].
[64] U.S. Fish and Wildlife Service, 1985. Recovery Plan for the San Francisco Garter Snake, *Thamnophis sirtalis tetrataenia*. U.S. Fish and Wildlife Service, Region 1, Portland, Oregon. 77 pp.
[65] Marion S, Davies A, Demsar U, Irvine JR, Stephens PA, Long J. 2020. A systematic review of methods for studying the impacts of outdoor recreation on terrestrial wildlife. Global Ecology and Conservation 22:1-15.

at the individual level, they can amount to population-level effects if numerous individuals are affected over space and time.[66]

Outdoor recreation often causes wildlife to shift their activity patterns or completely avoid otherwise suitable habitat. Reed et al. (2019) found that bobcat, gray fox, mule deer, and northern raccoon were less active in areas with higher levels of human recreation.[67] Bobcat habitat use was more strongly negatively associated with human recreation than urban development, which also decreased the probability of habitat use. The collective results of several studies suggest that some species, including the mule deer, may disappear altogether if human (recreation) activity is too high.[68] In addition to altering habitat use and wildlife abundance, human activities can change animal activity patterns. For example, studies have shown that some species (e.g., bobcat, deer, and coyote) may avoid recreation areas by switching to more nocturnal activities, which can disrupt predator-prey dynamics.[69]

The negative effects of recreation on wildlife populations generally occur in response to chronic disturbance (e.g., deer are repeatedly flushed from habitat near trails). However, a single disturbance event can have population-level effects on some wildlife taxa, such as bats.[70] Bats play an essential role in pest control and they serve as pollinators and seed dispersers of many plants that are important to humans. Boyles et al. (2011) estimated that the economic value of bats to the U.S. agriculture industry is $3.7 billion to $53 billion per year (approximately $363,757 per year in San Mateo County).[71] Tree-roosting bats most likely occur in the study area due to the abundance of mature trees in close proximity to preferred foraging habitat (many bat species forage near ponds, streams, and other water sources).[72]

A bat roost site can contain hundreds of bats.[73] Because bats are extremely sensitive to disturbance, noise and other forms of human activity can cause bats to abandon their roost(s).[74] This can have population-level effects in two ways. First, the functional loss of the roost site can reduce opportunities for reproduction because suitable maternity roost sites are the limiting

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66 *Ibid.*
67 Reed SE, Larson CL, Crooks KR. 2019. Effects of Human Use of NCCP Reserves on Reptile and Mammal Species in San Diego. Wildlife Conservation Society Agreement No/LAG #: P1582100.
68 *Ibid. See also* Lucas E. 2020. Recreation-related disturbance to wildlife in California – better planning for and management of recreation are vital to conserve wildlife in protected areas where recreation occurs. California Fish and Wildlife, Recreation Special Issue 29-51.
69 Lucas E. 2020. Recreation-related disturbance to wildlife in California – better planning for and management of recreation are vital to conserve wildlife in protected areas where recreation occurs. California Fish and Wildlife, Recreation Special Issue 29-51.
70 Western Bat Working Group. 2005 (Update). Species Accounts. Available at: <http://wbwg.org/western-bat-species>. (Accessed Feb 21, 2021).
71 Boyles JG, Cryan PM, McCracken GF, Kunz TH. 2011. Economic Importance of Bats in Agriculture. Science 332:41-42. *County-level data available at*: <https://science.sciencemag.org/content/suppl/2011/03/31/332.6025.41.DC1>
72 California Department of Fish and Wildlife. California Interagency Wildlife Task Group. 2014. CWHR version 9.0 personal computer program. Sacramento, CA. Available at: <https://wildlife.ca.gov/Data/CWHR/Life-History-and-Range>.
73 Western Bat Working Group. 2005 (Update). Species Accounts. Available at: <http://wbwg.org/western-bat-species>. (Accessed Feb 21, 2021).
74 *Ibid.*

factor for most bat populations.[75] Second, abandonment of a maternity roost can interrupt essential brooding activities and cause mortality of flightless pups. Similarly, impacts to wintering roosts can have population-level effects because the metabolic cost of waking bats from hibernation can be high enough to reduce energy supplies to a level where survival is not possible.[76]

Impacts on Habitat

Trails directly remove habitat for plants and animals. Initially, habitat loss occurs when vegetation and habitat elements (e.g., burrows, logs) are removed to construct the trail. After the trail is constructed, additional habitat loss occurs due to trail users that purposely or inadvertently step (or ride) off the trail and crush or otherwise damage plants and soils. This results in trail widening. Trail widening often occurs when the trail has not been properly designed, or is improperly used. For example, trails that do not have proper drainage structures will develop wet or muddy spots that trail users will step (or ride) around. Indeed, Evju and others (2021) found that soil moisture was the most significant predictor for trail widening, and that trail widening was greater when a large proportion of the trail users were mountain bikers.[77] During my site visits I observed locations where trail users had created parallel trails to avoid wet sections of the designated trail (Figure 19). Even when trails are dry, trail users may be forced to step (or ride) off of the trail if it does not have adequate passing space. Several trail segments in the study area are too narrow to accommodate both hikers and bikers, and during my site visits there were several occasions when I was forced to step off of the trail to accommodate passing cyclists.

Another way in which trail users can cause habitat loss is through creation of shortcuts or other unauthorized trail routes. Over time, unauthorized trails can cause more habitat loss, degradation, and fragmentation than designated trails.[78] Even where unauthorized trails occupy a relatively small proportion of a landscape, they can be very detrimental to wildlife and their habitat. For example, research has shown that wildlife has stronger reactions to off-trail activities because on-trail activities are more predictable (to wildlife).[79] All user groups tend to create and use unauthorized trails.[80] However, research indicates mountain bikers increasingly create unauthorized trails because they seek more challenging, wider-ranging, or free-riding

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[75] *Ibid.*

[76] Johnston D, Tatarian G, Pierson E. 2004. California Bat Mitigation Techniques, Solutions, and Effectiveness. p. 30.

[77] Evju M, Hagen D, Jokerud M, Olsen SL, Selvaag SK, Vistad OI. 2021. Effects of mountain biking versus hiking on trails under different environmental conditions. Journal of Environmental Management 278(2):111554.

[78] Lucas E. 2020. A review of trail-related fragmentation, unauthorized trails, and other aspects of recreation ecology in protected areas. California Fish and Wildlife, Recreation Special Issue 95-125. *See also* Ballantyne M, Gudes O, Pickering CM. 2014. Recreational trails are an important cause of fragmentation in endangered urban forests: a case study from Australia. Landscape and Urban Planning 130:112–124.

[79] *Ibid*. *See also* Mitrovich M, Larson CL, Bar-Rows K, Beck M, Unger M. 2020. Balancing conservation and recreation. California Fish and Wildlife, Recreation Special Issue 11-28. *See also* Taylor A, Knight R. 2003. Wildlife Responses to Recreation and Associated Visitor Perceptions. Ecological Applications 13(4):951-963.

[80] Hennings L. 2017. Hiking, mountain biking and equestrian use in natural areas: a recreation ecology literature review. Metro Parks and Nature, Portland, OR, USA.

opportunities.[81] I observed several areas where trail users had created shortcuts or other unauthorized trails (Figures 20 and 21). A few locations contained a substantial number of shortcuts, resulting in a "spider web" of cleared areas.

Fragmentation and Trail Density

In addition to direct impacts to habitat, trail construction causes habitat fragmentation, which occurs when large habitat areas or "patches" are broken up into smaller pieces. Many species, including most large mammals and birds, cannot maintain viable populations in small habitat patches, which leads to local extinction and loss of biodiversity. In addition, fragmentation commonly disrupts ecosystem processes and can interact with other forms of human disturbance in ways that cause significant landscape transformations. For example, trails can promote invasion of exotic species that outcompete natives and cause further losses of habitat and biodiversity. Although the effects of fragmentation vary among species, fragmentation generally favors exotic and generalist species at the expense of native species that have narrow habitat requirements (i.e., "specialists").

Trails act as a barrier to some species.[82] In some instances, the organism cannot cross the trail due to a physical barrier, such as a berm or verge that was created when a trail was constructed across a steep slope. However, just because an animal can physically cross the trail does not mean it will do so. Most trails lack vegetation and other structural elements (e.g., logs) that provide cover. Therefore, many prey species will avoid crossing trails because it exposes them to predators (or humans, which are perceived as predators).[83]

Access to water sources is critical to wildlife. The Lake Loop Trail and Canyon Creek Trail are located immediately adjacent to the primary water sources in the study area. In addition to posing a direct threat to aquatic reptiles and amphibians, these trails create a functional barrier to water access, decrease vegetative cover at the water source, and potentially impact water quality through erosion and sedimentation.

The effects that trails have on habitat fragmentation extend considerable distances beyond the trails themselves. Many wildlife species are intolerant of humans and thus avoid using habitats near trails. Behavioral avoidance of habitat is termed "functional habitat loss." The extent of functional habitat loss caused by recreational trails is dependent on several variables (e.g., species, topography, and intensity of trail use), but may extend several hundred meters beyond

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[81] Davies C, Newsome D. 2009. Mountain bike activity in natural areas: impacts, assessment and implications for management—a case study from John Forrest National Park, Western Australia. CRC for Sustainable Tourism Pty, Australia.

[82] Burgin S, Hardiman N. 2012. Is the evolving sport of mountain biking compatible with fauna conservation in national parks? Australian Zoologist 36:201–208. *See also* Clark BK, Clark BS, Johnson LA, Haynie MT. 2001. Influence of Roads on Movements of Small Mammals. The Southwestern Naturalist 46(3):338-344. *See also* Marsh DM, Milam DS, Gorham NP, Beckman NG. 2005. Forest Roads as Partial Barriers to Terrestrial Salamander Movement. Conservation Biology 19(6):2004-2008.

[83] *Ibid.*

the trail.[84] If alternate habitat is available, many species will move to areas farther from trails to avoid humans and recreation-related disturbance. However, if alternate habitat is not available, animals are forced to use habitat within the trail's zone of influence. This often results in negative behavioral or physiological reactions, which in turn affect reproductive or survival rates, and ultimately, persistence of wildlife populations and communities.[85]

Trail density is one of the main factors affecting wildlife in open space recreation areas.[86] The greater the trail density, the fewer options there are for wildlife to find suitable habitat away from the trails and their corresponding zones of influence. This is especially true in urbanized areas where the open space is essentially a habitat "island." During the site visits I observed that: (1) the study area has several redundant trails, and (2) there are trails throughout all portions of the study area (although some are unauthorized trails) (Figure 22). This has resulted in an extremely high density of trails, some of which appear to have no independent function or added recreational value. Based on measurements taken on Google Earth imagery, almost all of the habitat in the study area is within 100 meters of a trail, effectively reducing functional habitat to a fraction of the total study area. The high density of trails in the study area is undoubtedly having an effect on the natural environment and its function as wildlife habitat.

<u>Dogs</u>

Leashed dogs are allowed in the study area. Dogs negatively impact wildlife in three ways: (1) by causing direct mortality of wildlife through predatory action, (2) by disrupting normal behavior, which can affect population parameters (e.g., reproductive success), and (3) through disease transmission.[87] These impacts can be significant, especially to special-status species, which are generally more prone to population decline.[88]

Because many wildlife species view dogs as a threat, even leashed dogs can have adverse effects on wildlife.[89] Banks and Bryant (2007) showed that dog walking in woodland caused a 35% reduction in bird diversity and a 41% reduction in bird abundance.[90] Based on their review of 133 publications, Weston et al. (2014) reported: "[s]tudies presenting results on how wildlife

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[84] Dertien JS, Larson CL, Reed SE. 2018. Adaptive management strategy for science-based stewardship of recreation to maintain wildlife habitat connectivity. Wildlife Conservation Society, Americas Program, Bronx, NY, USA.
[85] Purdy KG, Goff GR, Decker DJ, Pomerantz GA, Connelly NA. 1987. A Guide to Managing Human Activity on National Wildlife Refuges. Human Dimensions Research Unit, Department of Natural Resources, Cornell University, Ithaca, New York, USA. *See also* Richardson CT, Miller CK. 1997. Recommendations for Protecting Raptors from Human Disturbance: A Review. Wildlife Society Bulletin 25(3):634-638. *See also* Lucas E. 2020. Recreation-related disturbance to wildlife in California – better planning for and management of recreation are vital to conserve wildlife in protected areas where recreation occurs. California Fish and Wildlife, Recreation Special Issue 29-51.
[86] Lucas E. 2020. Recreation-related disturbance to wildlife in California – better planning for and management of recreation are vital to conserve wildlife in protected areas where recreation occurs. California Fish and Wildlife, Recreation Special Issue 29-51.
[87] Weston MA, Fitzsimons JA, Wescott G, Miller KK, Ekanayake KB, Schneider T. 2014. Bark in the park: A review of domestic dogs in parks. Environmental Management 54:373-382.
[88] *Ibid.*
[89] Banks PB, Bryant JV. 2007. Four-legged friend or foe? Dog walking displaces native birds from natural areas. Biology Letters 3:611-613.
[90] *Ibid.*

reacts to dogs report that flushing behavior of mammals and birds is usually greater when pedestrians are accompanied by a dog compared to pedestrians walking alone."[91]

Effects on Populations and Communities

The effects of trails and human activities on wildlife populations are species-specific. While populations of most species are negatively affected, populations of a few species may benefit. Unfortunately, species that benefit from trails tend to be habitat generalists, exotic species, or disturbance-adapted mesopredators (i.e., smaller carnivores such as crows, ravens, jays, raccoons, skunks, foxes, and domestic cats).[92] These species can exacerbate the negative effects of recreational trails and cause further shifts in wildlife community composition. For example, Crooks and Soulé (1999) provided evidence that even modest increases in predation pressure from mesopredators, in conjunction with habitat fragmentation effects, may quickly drive native prey species to extinction.[93] Miller and others (1998) concluded that recreational trails as narrow as one meter (three feet) wide had negative impacts on breeding bird communities.[94] Negative impacts included decreased nesting and nestling survival rates near trails, altered bird species composition near trails, and increased nest predation by skunks, racoons and foxes using the clearings as corridors.

Blair and Launer (1997) conducted a study focusing on 10 native oak woodland species of butterflies near Palo Alto. They concluded that even small perturbations by hikers and joggers in a recreational area led to: (1) a loss in the number of butterfly species (species richness) of the original oak-woodland community compared to the number of these species in a biological preserve with no recreation, and (2) a lower number of butterflies (abundance) in the recreational area compared to the biological preserve.[95] The authors also concluded that multi-use areas may not adequately preserve butterfly species diversity.

The effects of recreational trails are not limited to negative impacts on birds and butterflies. Studies have also shown negative impacts on plants, reptiles, amphibians, and mammals.[96] Collectively, scientific studies across various plant and animal taxa have shown that, over time, recreational trails generally have the following effects on the ecological community:

1. Decline in native species presence and abundance, potentially to the point of extirpation of some species.

[91] Weston MA, Fitzsimons JA, Wescott G, Miller KK, Ekanayake KB, Schneider T. 2014. Bark in the park: A review of domestic dogs in parks. Environmental Management 54:373-382.
[92] Jordan M (*and references therein*). 2000. Ecological Impacts of Recreational Use of Trails: A Literature Review. 6 pp. Available at: <http://www.myxyz.org/phmurphy/dog/RecTrailsImpactLitSurvey.pdf>. *See also* Reed SE, Merenlender AM. 2008. Quiet, Nonconsumptive Recreation Reduces Protected Area Effectiveness. Conservation Letters 1:146–154.
[93] Crooks KR, Soulé ME. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563-566.
[94] Miller SG, Knight RL, Miller CK. 1998. Influence of Recreational Trails on Breeding Bird Communities. Ecological Applications 8(1):162-169.
[95] Blair RB, Launer AE. 1997. Butterfly diversity and human land use: species assemblages along an urban gradient. Biological Conservation 80:113-125.
[96] *See* Lucas E. 2020. Recreation-related disturbance to wildlife in California – better planning for and management of recreation are vital to conserve wildlife in protected areas where recreation occurs. California Fish and Wildlife, Recreation Special Issue 29-51.

2. Shift in community composition: common species or generalists increase, while uncommon species or specialists decrease.
3. Vegetation becomes less abundant (reduced density and cover) and has reduced stature.
4. Overall decline in species richness, biodiversity, and ecosystem functions.

5. CONCLUSIONS

My assessment has led to the following conclusions:

1. The trails and associated recreational uses have caused significant negative effects on the environment. Many of the negative effects are due to improper trail layout, design, usage, and management. The severity and spatial extent of negative effects is likely to worsen over time unless there is a shift in the land management strategy.
2. The current distribution and density of trails significantly reduces functional habitat in the study area and is incompatible with the conservation goals and policies established in the City's General Plan.
3. Many of the trails violate the provisions of the Master Plan, especially with respect to trail use designations and design guidelines. They also violate accepted standards for trail sustainability and resource conservation.
4. The hillside and marsh trails in the Brooks Preserve violate conditions of the land donation. John S. Brooks donated the land under the condition that it be "maintained in perpetuity as an unspoiled wild area or 'green belt' to preserve the trees and natural environment."[97] Construction of the hillside and marsh trails[98] has eliminated trees and degraded the natural environment through impacts to soils, hydrology, and habitat.[99] As a result, these trails violate the requirement that the Preserve be maintained as an "unspoiled wild area."
5. Sensitive riparian habitat within the study area has not been afforded protections prescribed in City policies, resulting in significant impacts to habitat for sensitive plant and animal species noted in City documents.
6. Trail construction has violated state regulations pertaining to the protection of riparian resources, and potentially state and federal regulations pertaining to protection of aquatic resources and water quality.

[97] *See* 29 Nov 1977 letter from HT Stearns, executor, to F Holland, Treasurer for the City of Belmont.

[98] The western portion of the marsh trail is in the Brooks Preserve, whereas the eastern portion is in Water Dog Lake Park.

[99] As opposed to the hillside and marsh trails, the Lake Road and John Brooks trails were constructed on old dirt roads that followed the contours of the land. Thus, they did not have comparable impacts on the ability to preserve trees and the natural environment. *See* City of Belmont. 2012 Nov 7. Staff Report from the Parks and Recreation Commission regarding discussion of Belmont's Open Space, including current condition, management, and future planning.

6. RECOMMENDATIONS

1. The following trails should be permanently closed and revegetated:
    a. The marsh trail in the Brooks Preserve (due to impacts on special-status species, riparian habitat and water quality, and because it violates the terms of the land donation).
    b. The hillside trail in the Brooks Preserve (due to incompatible slopes, erosion, impacts on oak woodland habitat, and because it violates the terms of the land donation).
    c. The segment of the Finch Trail that runs parallel to the Finch Bypass Trail (due to redundancy and impacts to mature woodland habitat).
    d. The eastern segment of the Rambler Trail (due to redundancy, proliferation of unauthorized spur trails, severity of damage to soils and vegetation, fragmentation of habitat, and impacts to riparian habitat bisected by the trail).
    e. The Canyon Creek Trail (due to redundancy, direct impacts to riparian habitat, and stream degradation).
    f. The Lake Loop Trail (due to impacts on wildlife, and potential impacts to riparian habitat and water quality).
    g. All unauthorized trails.
2. The number of stream crossings should be minimized to the maximum possible extent. Stream crossing that remain should be modified to reduce impacts on soils, water quality, and aquatic habitat. Where feasible, dry crossings (bridges) should be constructed at elevations above the highest potential water level. In addition, the City should devise a strategy for preventing trail users from bypassing the existing dry crossings (bridges).
3. The City should implement measures to prevent additional impacts to special-status plants and animals that occur in the vicinity of trails. This will require focused surveys and data collection. If the City is unable to hire professional biologists to conducts the surveys, it should seek assistance from non-profit organizations (e.g., California Native Plant Society, SF Bay Wildlife Society, and local educational institutions) that would be willing to volunteer professional expertise.
4. The City should develop a strategy for adhering to the conservation goals and policies established in the City's General Plan. In addition, the City should develop concrete objectives for protecting soils, water quality, vegetation, and wildlife. All projects and maintenance activities should be evaluated on the basis of conformation with such objectives.
5. The City should prepare and implement a trail management plan that includes strategies for:
    a. reducing soil loss and improving the sustainability of designated trails.

b. routine monitoring to assess trail conditions (e.g., degradation) and the efficacy of resource protection measures.

c. preventing further use and proliferation of unauthorized trails.

d. closing inappropriate trails (i.e., unauthorized trails and unnecessarily redundant trails).

e. restoring habitat on unauthorized trails and trails to be decommissioned.

6. The California Oak Mortality Task Force has issued guidelines for minimizing the risk of spreading SOD.[100] To minimize the ecological impacts of SOD, the City should require trails crews to adhere to the California Oak Mortality Task Force guidelines.

7. The City should implement an "Early Detection Rapid Response" framework for invasive plant management.[101]

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[100] California Oak Mortality Task Force. 2014. Sudden Oak Death Guidelines for Arborists. 6 pp. Available at: <http://www.suddenoakdeath.org/>.

[101] *See* U.S. Department of the Interior. 2016. Safeguarding America's lands and waters from invasive species: A national framework for early detection and rapid response, Washington D.C., 55p. Available at: <https://edit.doi.gov/sites/doi.gov/files/National%20EDRR%20Framework.pdf>.

Figure 1. Trails hiked during site assessment (yellow highlighting).

Figure 2. Technical trail feature (descending turn) installed on the Brooks hillside trail.

Figure 3. Degradation of the eastern segment of the Rambler Trail.

Figure 4. Trail incision on the Brooks hillside trail.

Figure 5. Trail incision at the top of the Brooks marsh trail.


Figure 6. Gully on the Brooks Trail.


Figure 7. Gullies and active erosion on the Rambler Trail.

Figure 8. Tire ruts on the Brooks hillside trail.

Figure 9. Trail damage along the Canyon Creek Trail. Blue arrows depict direction of sediment transfer into the adjacent ephemeral stream.

Figure 10. Wet crossing at Belmont Creek.

Figure 11. Redundant crossings (red arrows) created by a trail shortcut at Belmont Creek.

Figure 12. Dry crossing being bypassed by trail users on the Canyon Creek Trail.

Figure 13. Brooks marsh trail (through riparian habitat).

Figure 14. Trail shortcuts through riparian habitat along the Brooks marsh trail.

Figure 15. Willow tree that had been severely trimmed along the Brooks marsh trail.

Figure 16. Portion of riparian tree that had been felled along the Brooks marsh trail.

Figure 17. Vegetative debris that had been thrown into Belmont Creek.

Figure 18. Stand of pampas grass (an invasive species) near the Brooks hillside trail.

Figure 19. Parallel trail (red arrows) created adjacent to the Brooks Trail.

Figure 20. Shortcut created on the Brooks hillside trail.

Figure 21. Unauthorized trail on the slope above the Upper Creek Trail.

Figure 22. Habitat fragmentation caused by unauthorized trails and unnecessarily redundant trails in the southeast corner of Hidden Canyon Open Space.

EXHIBIT C

esa

ECOSPHERE

Extent and drivers of vegetation type conversion in Southern California chaparral

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Abstract. The native chaparral shrublands of Southern California support exceptional biodiversity and provide critical ecological services, but increased fire frequency threatens to extirpate much of the chaparral due to long regeneration times needed between fires for many species. When short fire intervals inhibit shrub recovery, this favors invasion of exotic herbaceous species, and vegetation type conversion from woody shrubs to grassland is therefore a serious ecological concern in this biodiversity hotspot. Despite a history of field studies documenting the detrimental effect of short-interval fire, the extent of vegetation type conversion and the conditions under which it occurs have not been documented at a landscape scale. Our objective was thus to provide an unbiased assessment of how and how much vegetation type conversion is occurring in Southern California chaparral. We used a chronosequence of aerial photographs to quantify percentage woody and herbaceous cover change from 1953 to 2016 across randomly sampled plots in San Diego County, then related conversion and decline to a range of explanatory variables including fire, proximity to human disturbance, and biophysical landscape characteristics. Within the 63-yr study period, there was substantial net woody cover loss, and in the plots that were initially more than 75% woody cover in 1953, 59% experienced a decline, with a mean woody cover loss of 22.5%. Of these, 28% heavily type-converted to the point that herbaceous vegetation covered more than 50% of the plot. The top drivers for woody conversion and decline included a fire interval shorter than 15 yr and total number of fires, actual evapotranspiration, and elevation. Although human land use variables were not strong independent contributors to either chaparral conversion or decline, 26% of the initial vegetated plots were directly converted to development or other human disturbance types. The combination of direct habitat loss and unintentional vegetation type conversion represents a substantial ecological impact in Southern California that can have far-reaching impacts via loss of ecological services and by increasing the flammability of the landscape in general. Efforts to reduce fire frequency will be key to preventing further losses.

Key words: annual grass; evapotranspiration; fire interval; habitat loss; invasive species; wildfire.

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Introduction

The most extensive vegetation type in Southern California consists of a diversity of drought-tolerant, evergreen, woody shrub species known as chaparral. The morphological and physiological characteristics of these shrublands, characteristic of all Mediterranean ecosystems (Keeley et al. 2012), contribute to numerous ecosystem services critical to human health and society

(Underwood et al. 2018) and support the rich biodiversity of the region (Keeley 2005). As in other Mediterranean regions, which are all biodiversity hotspots, chaparral is threatened by rapid global change, with too-frequent fire often ranking as the top threat (Franklin et al. 2014).

Although chaparral is generally resilient to periodic wildfire (Keeley and Syphard 2018*a*), uncharacteristically short intervals between fires may prevent sufficient post-fire recovery and gradually lead to replacement by alien herbaceous vegetation (Keeley and Brennan 2012, Syphard et al. 2019). Evidence for fire's potential to facilitate unintentional chaparral type conversion to grassland in California has been documented since the 1920s (Cooper 1922). Intentional type conversion using fire was practiced by Native Americans, Euro-American settlers, and middle 20th-century ranchers who did repeated burning to convert these dense woody shrublands into grasslands for economic reasons (Burcham 1955, Keeley and Fotheringham 2003). Recently, the role of fire in driving vegetation type changes in a number of conifer forest systems has been documented for western North America (Davis et al. 2019, Turner et al. 2019) and globally (Pausas 2015).

Despite the ecological importance of chaparral and its potential for decline under repeated fire, few efforts have been made to document the extent of chaparral vegetation type conversion across Southern California landscapes or to quantify the environmental conditions under which this change is most likely, in part because chaparral has historically been under-valued (Rundel 2018). On the other hand, there have been multiple studies evaluating the decline and conversion of drought-deciduous sage scrub species to herbaceous vegetation (Minnich and Dezzani 1998, Talluto and Suding 2008, Cox et al. 2014). Sage scrub, while often intermixed with chaparral, is generally located in lower-elevation parts of the landscape and tends to be more resilient to frequent fire (Westman and O'Leary 1986) and more vulnerable to nitrogen deposition (Fenn et al. 2010) than chaparral.

So far, most research on short-interval fire effects in chaparral has involved field experiments showing different species' sensitivities to short-interval fires relative to post-fire traits, that is, according to functional groups (e.g., Zedler et al. 1983, Haidinger and Keeley 1993, Keeley and Brennan 2012). Results of these studies, consistent with simulation experiments (Syphard et al. 2006), have found the most fire-sensitive chaparral species are obligate seeders that depend upon fire-cued seed germination and require a decade or more to recover after fire (Zedler et al. 1983, Jacobsen et al. 2004, Lippitt et al. 2012). Other work has shown that even resprouting chaparral can be eliminated if fire is frequent enough (Haidinger and Keeley 1993, Keeley and Brennan 2012). Although intervals of at least 5 to more than 15 yr are believed to be required to allow sufficient time for post-fire chaparral recovery (Zedler 1995), it remains unclear whether there is a specific minimum-interval threshold at which type conversion is most likely.

While our understanding of chaparral type conversion has come from localized field studies, increasing fire frequency in Southern California has the potential to drive widespread vegetation change, not only in coastal sage scrub ecosystems (Talluto and Suding 2008), but also in chaparral-dominated landscapes (Syphard et al. 2019), and this has prompted the need for more work at a landscape scale. Lippitt et al. (2012) found evidence for landscape-level chaparral displacement where fire intervals were shorter than five years, in lower-elevation areas near chaparral ecotones with xeric slopes and low moisture availability. This is consistent with other studies that documented shifting dominance from woody to herbaceous cover at low elevations or where there are low soil water moisture or drought conditions (Meng et al. 2014, Park et al. 2018, Syphard et al. 2019). Proximity to human disturbance has also been a significant correlate (Syphard et al. 2019).

Regarding fire interval, Meng et al. (2014) concluded, after failing to detect significant type conversion after short-interval fire via remote sensing across paired plots after 25 yr, that large-scale vegetation type conversion is unlikely to occur. However, it should be recognized that they were not documenting changes in vegetation over time, but rather they were using different sites at different points in time and making inferences about the role of their different histories. The gold standard in type conversion studies must be examination of how actual vegetation changes over time, and thus, we need studies that follow the same sites over time.

Beyond understanding the role of fire and other geographical co-variates in facilitating type conversion, there is a pressing need to determine whether widespread change is actually occurring. Despite the doubt raised by Meng et al. (2014), simple map overlays from the 1930s to 2013 suggest that large swaths of the Southern California landscape have already converted from shrubland to grassland, in areas of high fire frequency (Syphard et al. 2018). If these maps reflect real changes, this represents a serious ecological issue. The only way to truly quantify change is via long-term empirical work; but given the paucity of long-term field data, chronosequence methods using remote sensing or aerial photography offer the only alternative.

Recent work in the Santa Monica Mountains (Syphard et al. 2019) was the first to use historical aerial photography to quantify a chronosequence of chaparral vegetation change across an entire landscape and relate it to a range of drivers and landscape characteristics, although a similar approach was used in the San Francisco Bay area to document change among different vegetation types (Russell and McBride 2003). Although the work in the Santa Monica Mountains suggested that chaparral type conversion has likely been substantial, the results may have been biased because samples were selected purposely to identify plots that both had and had not converted from chaparral to herbaceous vegetation.

In this study, we aimed to provide an assessment of how much type conversion has occurred in Southern California chaparral by quantifying the percentage woody cover change from 1953 to 2016 in 916 randomly sampled plots distributed across historical aerial photographs in San Diego County. 1953 and 2016 were the earliest and latest dates for which we could obtain continual coverage across the study region. Similar to the approach used in Syphard et al. (2019) as described below, we calculated the percentage cover of woody shrublands and herbaceous vegetation, in addition to developed or disturbed land in all plots in both years, and then related decline of woody cover and conversion to herbaceous vegetation to a range of explanatory variables representing fire, proximity to human disturbance, and biophysical landscape characteristics. We asked the following questions:

1. How is the cover of woody chaparral shrublands changing over time, and how much is converting to herbaceous vegetation?
2. Is short-interval fire a key control of this decline, and what is the minimum fire interval where this change is significant?
3. What are the important geographical factors associated with unintentional woody cover decline, and are these similar to those in the Santa Monica Mountains?

Methods

Study area

The study area included the portion of San Diego County that overlaps the South Coast Ecoregion in California (Miles and Goudey 1997; Fig. 1), where chaparral is the most extensive vegetation, often distributed in a mosaic with native and exotic grasslands, drought-deciduous sage scrub, oak woodlands, and mixed conifer forests in higher elevations. San Diego County has a Mediterranean climate with cool, wet winters and hot, dry summers, and its high topographic heterogeneity and climatic heterogeneity contribute to exceptionally high levels of biodiversity; yet, the region has also experienced tremendous population growth and urban expansion, and thus also has the most threatened and endangered species in the continental United States (Dobson et al. 1997). The natural fire regime is characterized by periodic large, high-intensity crown fires driven by hot, dry Santa Ana winds that recur every autumn in addition to smaller fires that occur in the summer (Jin et al. 2015). More than 95% of fires are caused by humans (Keeley and Syphard 2018*b*); thus, fire frequency has increased across much of the landscape in response to population growth and urban expansion, and intervals between fires are now much shorter than pre-Euro-American settlement conditions (Safford and Van de Water 2014). The conversion of chaparral to herbaceous vegetation has already been documented in some parts of the county (Keeley and Brennan 2012, Lippitt et al. 2012).

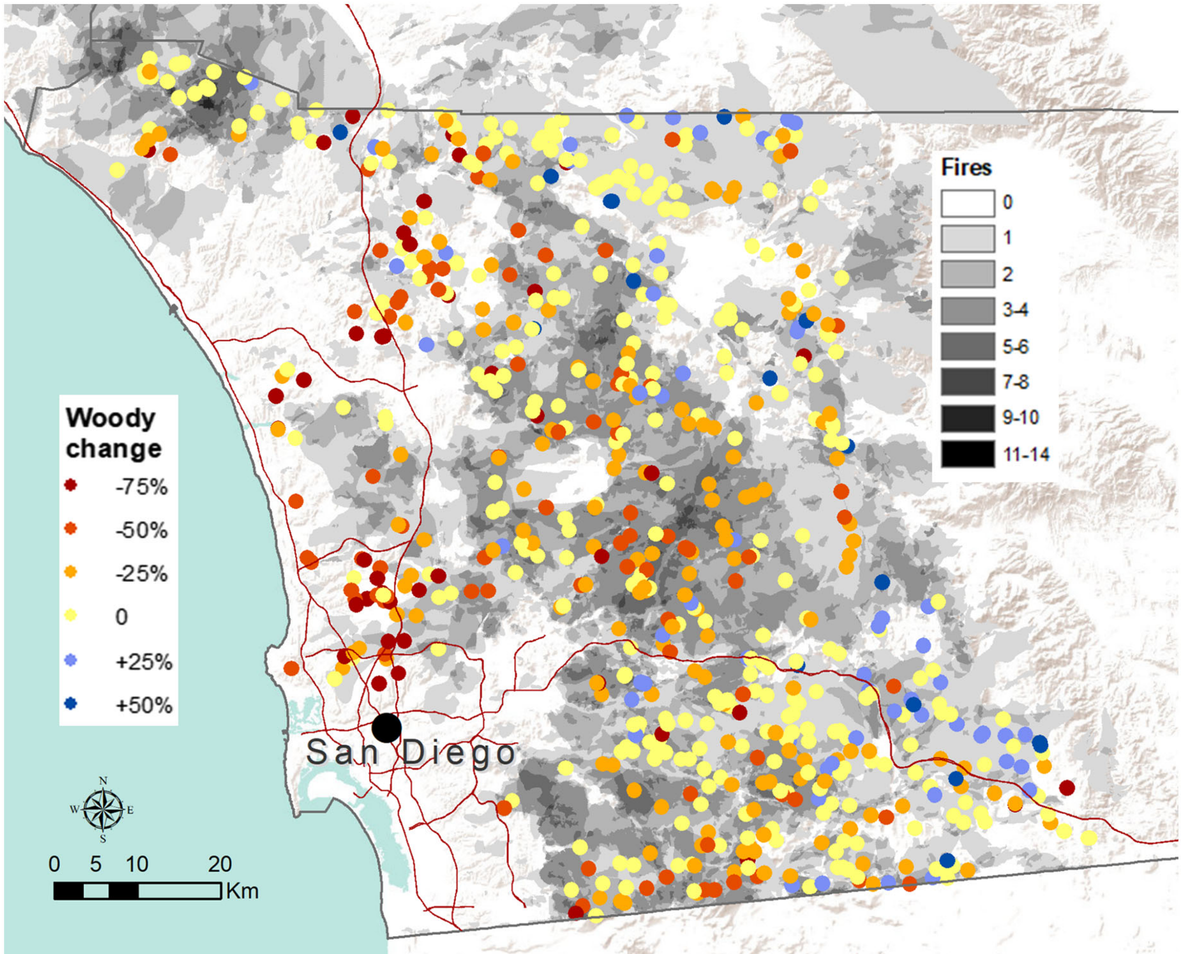

Fig. 1. Map of San Diego County with 771 plots overlaid showing the percentage change in woody cover from 1953 to 2016. These are the original 916 points with 145 removed due to fire within five years of the image date.

Random sampling and image interpretation

To quantify the extent and to identify the drivers of chaparral vegetation change, we generated a random sample of 1000 points, with a minimum of 90 m between points to avoid plot overlap, across the entire area mapped as chaparral in the 1930s on a historical vegetation map (Kelly et al. 2005). While chaparral may be interspersed with coastal sage scrub in some areas, restricting the initial conditions to chaparral in the 1930s map ensured that chaparral dominated the initial conditions. We then recorded the fates of these plots by 2016, allowing an unbiased sampling of potential change across chaparral-dominated areas of the vegetated landscape. Due to lack of imagery in some areas, we removed 84 plots, leaving an initial sample size of 916. As in Syphard et al. (2019), we created 30-m buffers around all points and quantified the type and percentage of cover within those 0.28-ha plots for image dates 1953 and 2016, which were the earliest and latest dates for which complete county coverage was available. The 1953 data were collected from images acquired from the University of California Santa Barbara Map and Image Library (http://mil.library.ucsb.edu/ap_indexes/FrameFinder), Flight AXN-1953, and were at the scale of 1:20,000, and the 2016 data were collected from images acquired from the National Agriculture Imagery Program (NAIP), available on an ArcGIS Server (https://gis.apfo.usda.gov/arcgis/rest/services), with a resolution of 60 cm.

To quantify woody cover transition and decline, we assigned each plot a number on an interval scale corresponding to percentage cover of woody chaparral vegetation, bare ground and grass, rock, urban development (paved roads and structures), or other type of human disturbance (e.g., agriculture, trails and dirt roads, fuel breaks). We were able to easily discern woody chaparral from herbaceous vegetation via the texture in the images. However, we could not discern drought-related dieback or mortality, as woody skeletons remain on the landscape until the next fire and still show chaparral. Therefore, the analysis of woody cover change did not account for drought-related adult mortality. For statistical analysis of the drivers of change, percentage cover was classified into four equal intervals of 25% cover of each class (0–25%; 26–50%; 51–75%; and 76–100%). To further characterize the nature of vegetation change, we added additional classes to indicate where there were almost pure stands of a cover type (95–100%) in addition to stands where the cover type was absent or minimally present (0–5%).

We overlaid a map of fire perimeters on the plots (Cal Fire perimeter data; http://frap.fire.ca.gov/data/frapgisdata-sw-fireperimeters_download), and further assessed burn scars in the imagery to identify and delete any plot that had experienced, or appeared to have experienced, a partial or complete burn within 5 yr of either image date (i.e., from 1948 to 1953 and from 1911 to 2016, n = 145). We did this to ensure that early post-fire recovery vegetation was not mistaken for longer-term vegetation change. Because the objective was to quantify change in woody cover (either positive or negative), we also deleted plots that had evidence of human disturbance or urban development in 1953 (n = 110) to ensure that the initial state was purely vegetated regardless of cover type. We quantified change in vegetation cover by plotting the distribution of cover type percentages in both time periods and by overlaying plots and subtracting the cover value (ordinal scale 1–4) in 1953 from that in 2016.

For statistical analysis of the drivers of chaparral decline and conversion to herbaceous vegetation, we used the subsample of the plots that were initially pure or almost pure stands of chaparral, that is, they had at least 75% woody cover in 1953. This restriction to relatively intact stands of chaparral ensured that the statistical analysis was focused on identifying and isolating those factors associated with chaparral type conversion and not to confound those with other types of vegetation change. This required the initial stand conditions to be chaparral. We further deleted plots that had either become developed or disturbed by human land use by 2016 because our focus here was on the drivers of unintentional vegetation type change of chaparral. This resulted in a sample size of 311 plots for statistical analysis of drivers of change. As in Syphard et al. (2019), we performed statistical analysis for two binary dependent variables. For the first, plots were split based on the criterion of 50% cover conversion from woody to herbaceous over the 63-yr study period (i.e., to the point in which herbaceous cover occupied at least 50% of the plot, hereafter "chaparral conversion"). For the other, we split the plots based on whether woody chaparral experienced at least a 25% conversion to herbaceous (hereafter "chaparral decline").

Explanatory variables

To identify the most important landscape drivers of vegetation type conversion, we considered a similar suite of landscape-scale variables as our analysis in the Santa Monica Mountains (Syphard et al. 2019), although we updated the list with a couple of additional variables (Table 1). Regardless of the native resolutions of the explanatory variables, we extracted data values from each spatial layer to correspond with our 30-m plot areas.

It is well established that soil characteristics and water balance mediate plant development and productivity (Franklin 1995), and potentially post-fire recovery, so we evaluated soil available water capacity (AWCL), derived from the California State Soil Geographic Database (STATSGO; Shirazi et al. 2001), which was one of the most important variables in the Santa Monica Mountains. In addition, we considered two variables we hypothesized may better represent soil moisture availability or drought conditions, including climatic water deficit and actual evapotranspiration, but because they were highly correlated, we only proceeded with actual evapotranspiration (AET). We obtained AET from a suite of climatic and water balance data produced by Flint and Flint (2012) using

Table 1. Description and scale of variables used in statistical analysis of vegetation type conversion in San Diego County, California, USA.

Variable	Description and source	Scale
Vegetation change (dependent variables)		
Chaparral conversion	Plot that was mostly chaparral in 1953 and mostly grass in 2016, compared to no vegetation change or lower percentage decline	30-m buffers around points (0.28 ha), binary
Chaparral decline	Plot that was fully chaparral in 1953 that experienced at least a 25% conversion to grass in 2016, compared to no vegetation change	30-m buffers around points (0.28 ha), binary
Explanatory variables		
Nitrogen deposition	Annual deposition or reduced and oxidized nitrogen (Tonnesen et al. 2007)	4 km, kilogram of nitrogen per hectare
Number of fires	Total number of fires that occurred since 1898, Cal Fire perimeter database	30 m, calculated at plot location
Minimum fire interval	Shortest number of years between any two fires in the record, or as observed via imagery	30 m, calculated at plot location
Available water holding capacity (AWCL)	The amount of available water in the soil that can be absorbed by a plant (Shirazi et al. 2001)	1 km, inches of water available in soil profile
Elevation	U.S. Geological Survey digital elevation model	30 m
Slope	Derived from elevation	30 m
Topographic heterogeneity	Range of elevation values within 270-m radius of center cell	90 m, index from 0 to 1
Actual evapotranspiration	Total annual water evaporated from surface and transpired by plants, assuming unlimited water	270 m, mm summed annually and averaged from 1980 to 2010
Distance to all roads	TIGER line, Exclude 4WD and OHV roads; Combine others, including RRs. TIGER Roads 2015, U.S. Department of Commerce, U.S. Census Bureau	Euclidean distance, 30 m
Structure density	Spatial interpolation of digitized points at 1-km radius (Syphard et al. 2013*a*, *b*), including structures up to 2015	30 m
Distance to Wildland–Urban Interface (WUI)	Euclidean distance to interface or intermix WUI in 2010 (Radeloff et al. 2018)	30 m

the California Basin Characterization Model (Table 1). AET is derived from modeled calculations based on topography, soil, precipitation, and temperature, and we used the 30-yr baseline statistical summaries averaged from annual data from 1981 to 2010 at 270-m resolution. In addition to AWCL and AET, we again considered the potential effect of nitrogen deposition to moderate soil fertility using a 2002 map representing total annual deposition of reduced and oxidized nitrogen (kilograms of nitrogen per hectare per year) at 4-km resolution (Tonnesen et al. 2007).

As with soil and water balance data, topographic variables affect energy and moisture balance, in addition to fire behavior, and are often important indirect determinants of plant species' distributions (Franklin 1995). We explored the same three topographic variables that we used previously, including slope, elevation, and topographic heterogeneity (Table 1).

To evaluate the effect of fire frequency on vegetation change, we overlaid the Cal Fire perimeter data, which included fires from 1898 to 2016, on all plots and summed the number of times each plot had burned. In addition, we calculated the interval in years among all the fires that had occurred on each plot to obtain a minimum interval between fires. For those plots in which no fires occurred, we estimated the minimum interval to be the length of time in the fire record, which would be 118 yr. For plots that only burned once, we assessed the minimum to be either the smallest number between the 2016 and the fire date or between the fire date and the beginning of the fire record. For fires burning more than once, we calculated the number of years between all fires and between the earliest and latest fires with the beginning and end of the record, then took the minimum of those numbers.

Whereas public lands and parks extend across vast swaths of the Santa Monica Mountains, the

San Diego County study area has more extensively dispersed areas of privately owned lands with low–medium density development and Wildland–Urban Interface (WUI; Radeloff et al. 2018). Therefore, instead of evaluating distance to trails, which cover much of the Santa Monica Mountains but only a fraction of San Diego County, we considered two variables relating to human development, including structure density and distance to the Wildland–Urban Interface (WUI). The structure density map was derived via a simple density interpolation, with a 1-km search radius at 30-m resolution, of digitized point locations representing all structures in the study area, as in Syphard et al. (2013*a*) but with structures digitized through 2015. The WUI is defined as the area where development meets (interface) or intermingles with (intermix) undeveloped wildland vegetation; it is where fires are most likely to start and destroy structures (Radeloff et al. 2018) and is associated with a range of other human–natural conflicts and disturbances (Bar-Massada et al. 2014). To evaluate the potential influence of the WUI on landscape disturbance that could facilitate vegetation type conversion, we used the WUI data available via Radeloff et al. (2018) for 2010, collapsing the two classes of WUI into one and deriving the Euclidean distance to these areas at 30-m resolution. We also evaluated the Euclidean distance to roads at 30 m, using the 2015 Topographically Integrated Geographic Encoding and Referencing System TIGER/Line files from the U.S. Census 2010.

Statistical analysis of type conversion drivers

We used two types of statistical analysis to identify the most important landscape drivers of chaparral conversion and decline. The first quantified the relative independent importance of all 11 explanatory variables using the hier.part package in RStudio version 1.1.463 (MacNally and Walsh 2004, RStudio Team 2015). This approach was used to understand and compare the isolated effect of each variable on vegetation change, regardless of other variables' effect. Given our two binary dependent variables, we parameterized the statistical modeling algorithm to use a binomial response for each and to iteratively calculate the log likelihood goodness of fit for a hierarchy of regression models on all combinations of explanatory variables, thereby measuring all variables' independent effect.

To account for variable interactions and thresholds, we created multivariate classification tree models (Breiman et al. 1984). Classification trees are a nonparametric, unsupervised clustering approach that iteratively splits explanatory variable data into increasingly homogenous clusters that best differentiate between the two classes of the binomial response variable. The tree is structured so that the most influential variable is at the top, with the data falling into two classes that are split according to the critical threshold that best divides them. The tree continues to branch out with similar thresholds and splits, with the most important variables at the top and the least important at the bottom. We created trees for both binary response variables, considering all explanatory variables, using the rpart and rpart.-plot packages in RStudio 1.1.463 (RStudio Team 2015). To assess model fit, we calculated the area under the curve (AUC) for receiver operating characteristic (ROC) plots (Hanley and McNeil 1982).

Results

Overall, most plots experienced substantial woody cover decline, as illustrated by the distribution of 1953 and 2016 plots across cover classes, both when divided into equal intervals (Fig. 2a) and when pure woody and grass were separated out (Fig. 2b). Fewer than half of the plots remained the same over time (307 of 661, or 46%), but there were some plots that gained woody cover during the study period (11% overall), with 58 plots gaining 25% woody cover, 16 plots gaining 50% woody cover, and one plot increasing cover by 75%. Most of these cover gains were located on the eastern portion of the study area (Fig. 1). Calculations of net cover change showed substantially larger woody cover decline than increase (Fig. 3).

Of the 661 plots that were not developed or disturbed in 1953, nor had experienced a burn within five years of either image date, 51 (8%) became partially to completely developed (i.e., paved or with a structure on it), and an additional 116 (18%) experienced some type of human disturbance by 2016. Although specific disturbance types were difficult to classify,

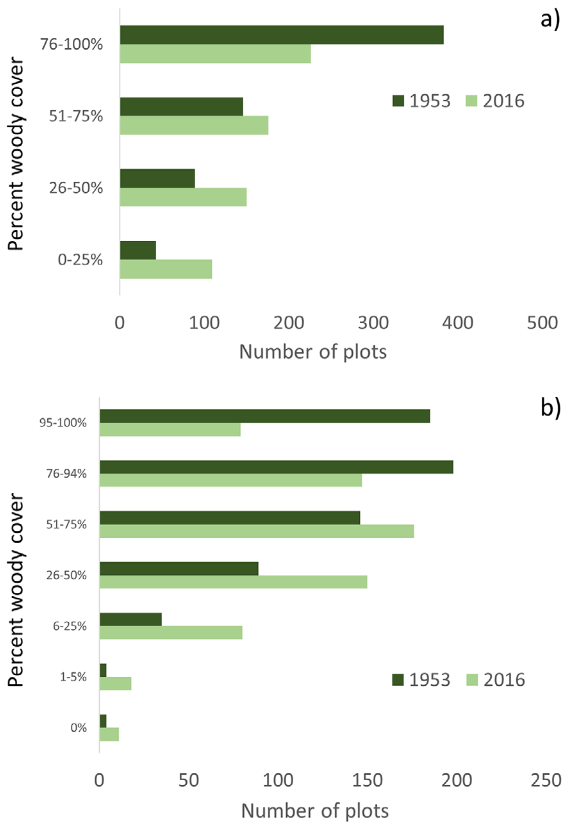

Fig. 2. Number of vegetation plots in San Diego County distributed within woody cover classes in 1953 and 2016, with (a) equal interval classification and (b) a classification that separates pure woody (95–110%) and pure herbaceous (0–5%) classes.

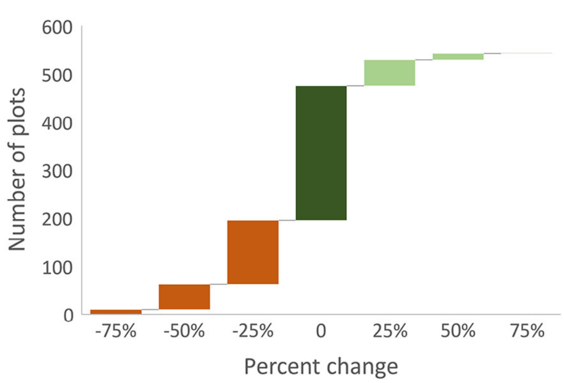

Fig. 3. Direction and amount of change among woody cover classes from 1953 to 2016 in San Diego County.

approximately 40% had become either a dirt road, fuel break, or trail; approximately 35% was some type of agriculture, orchard, nursery, or cultivated land use; approximately 20% had been cleared, potentially for fire management or new development; and the remaining 5% included miscellaneous uses, including reservoirs, planting with shade trees, mining, or ball park. Of the 311 plots that had more than 75% woody cover in 1953, 185 (59%) experienced woody cover decline, with a mean loss of 22.5% cover. Of these, 51 (28%) fully type-converted (more than 50% woody cover loss to herbaceous).

Most of the factors that had the highest percent independent contribution to chaparral conversion were the same as those with the highest contribution to chaparral decline, with slight changes in variable rankings (Fig. 4). The top drivers for both included minimum fire interval and total number of fires, actual evapotranspiration, and elevation, although there was some variation depending on whether the response was chaparral conversion or decline. The human land use variables were not strong independent contributors to either chaparral conversion or decline.

The classification trees (Fig. 5a, b) were also similar for chaparral conversion and decline. In both, the most important variable distinguishing whether a plot converted or declined was minimum fire interval, both with a threshold of 15 yr. For chaparral conversion, there were no other splits in the group with longer fire intervals; but for chaparral decline, the plots with longer intervals were next best separated by slope (steep slopes more likely to convert), then AET (low AET most likely to convert). Where there was not a minimum 15-yr interval between fires, the next most important factor was AET for both trees, with less important factors being high nitrogen deposition and close proximity to the WUI. The training AUC for the classification tree of chaparral conversion was 0.82 and for chaparral decline was 0.84.

Discussion

Despite growing recognition that chaparral type conversion is one of the Southern California's most serious ecological issues, no studies until now have provided empirical evidence for

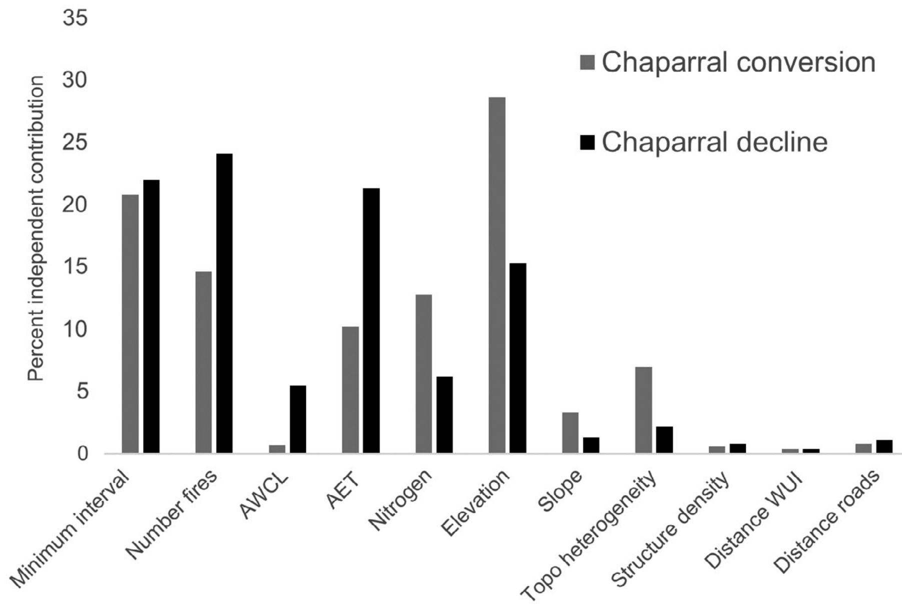

Fig. 4. Hierarchical partitioning results showing percent independent contribution of variables explaining chaparral decline and conversion to herbaceous cover from 1953 to 2016 in San Diego County, California, USA.

the extent and amount of landscape-scale woody vegetation decline and conversion into herbaceous cover. Although some studies have provided indirect evidence for extensive type conversion (Park et al. 2018, Syphard et al. 2019), there has also been debate over the feasibility of widespread change, particularly as driven by short-interval fire (Meng et al. 2014). Here, we used a random sampling approach to assess the extent of woody cover decline over a period of 53 yr in San Diego County and found strong evidence for widespread shifts in vegetation type dominance by 2016. Regardless of the initial amount of woody cover in the plots in 1953, the trajectory was consistently negative, with few plots having increased in cover in the same period. Given this substantial decline, only 16% of the initial plots that were almost entirely woody fully type-converted, highlighting that vegetation type change is a gradual process that cannot be fully captured, and in fact is underestimated, by classing vegetation into only two states.

The process of chaparral type conversion likely begins via landscape simplification, whereas a cycle of repeated short-interval fires begins, and with each subsequent fire, some chaparral species are extirpated until woody dominance is lost (Zedler 1995). In some parts of the landscape, there may even be an initial transition to drought-deciduous coastal sage scrub that tends to be more resilient to short-interval fires and more widely dispersed than chaparral (Westman and O'Leary 1986, Syphard et al. 2006). It is possible that as woody chaparral degraded in this study, that some transitioned to sage scrub. If this would have happened, it would have been difficult to discern the type change if the percentage of woody cover remained the same. However, given that sage scrub is often more open than chaparral, that would have been accounted for in the calculations of woody cover change. Most of the earlier field studies on fire-driven chaparral conversion to herbaceous vegetation focused on different sensitivities of post-fire functional groups (e.g., Zedler et al. 1983, Haidinger and Keeley 1993, Jacobsen et al. 2004, Keeley and Brennan 2012) with consistent evidence that different species require different amounts of time before seed and bud banks can regenerate sufficiently to repopulate a stand. Although we could not distinguish species composition from air photographs, it makes sense that the rate of woody decline

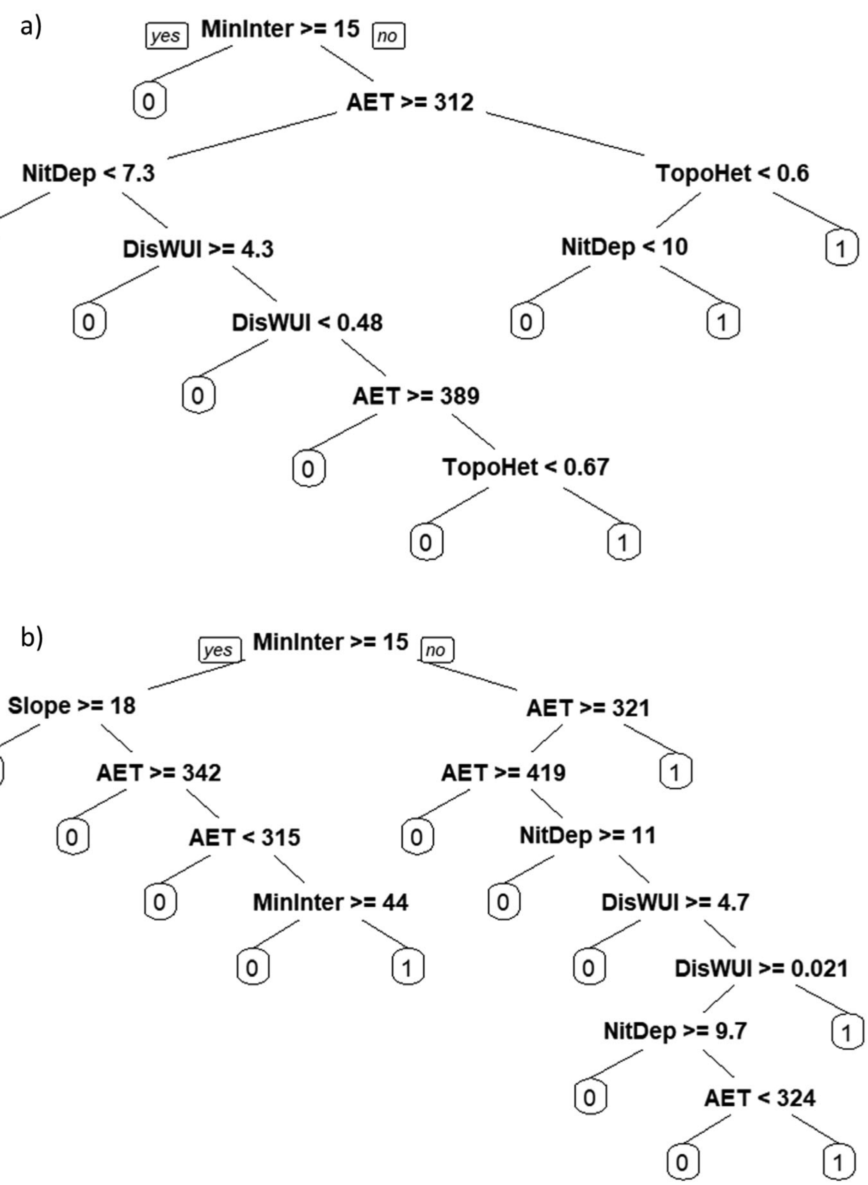

Fig. 5. Classification tree plots showing relationships among variables explaining (a) chaparral conversion and (b) chaparral decline from 1953 to 2016 in San Diego County.

may vary across the landscape depending on species' distributions and other environmental factors, many of which we explored here.

The role of fire was the most important factor distinguishing plots where woody vegetation converted to herbaceous or declined. This result is not surprising, as it is consistent with field studies and the results from the similar study in the Santa Monica Mountains (2019), and it thus underlines the primary role of fire in chaparral degradation and decline. As with Jacobsen et al. (2004) and Syphard et al. (2019), the primary mechanism here was minimum fire interval, more than total fire frequency. However, the threshold that best distinguished converted or declining plots was a minimum of 15 yr, whereas it was 10 yr in the Santa Monica Mountains. This longer interval, or threshold, suggests that either species composition in the plots sampled here consists of more fire-sensitive species, such as obligate or facultative seeders (as was shown in Lippitt et al. 2012); or there are certain environmental conditions here that contribute to longer times needed for chaparral post-fire regeneration.

Both in the Santa Monica Mountains (via AWCL) and here in San Diego County (via AET), the parts of the landscape most susceptible to drought or low soil moisture availability were also more likely to experience woody conversion or decline, which was also the case in Park et al. (2018). Extreme drought conditions have been shown to increase post-fire mortality of resprouts or seedlings, in addition to adult shrub mortality (Paddock et al. 2013, Ventura et al. 2016, Jacobsen and Pratt 2018), which could provide a competitive advantage to exotic annuals in the post-fire environment. Given that many of the plots in San Diego County do not receive the moisturizing benefits of coastal fog and that San Diego County is generally warmer and drier than the Santa Monica Mountains, this may explain why chaparral overall takes longer to recover here.

The important point here is that drought is of greatest importance in the post-fire environment, and thus, there could be serious implications if droughts were to increase under climate change. Drought interacts with fire to reduce post-fire recovery (Pratt et al. 2014), and when fires are frequent under drought conditions, this can exacerbate the invasion of non-native grasses. Certainly, one of the factors involved here is that the shrub life histories susceptible to short fire-return intervals are the obligate seeding mode, and obligate seeding species are most abundant on drier slopes (Keeley and Syphard 2018*b*); these are also the species must vulnerable physiologically to drought (Ventura et al. 2016), and thus, the association between type conversion and more arid sites is also related to functional type distribution.

There are other landscape differences between the Santa Monica Mountains and San Diego County that may explain other differences in environmental variable importance. For instance, there is a greater elevational gradient in San Diego County, which may be why elevation was more important here than topographic heterogeneity, at least when explored independently (both slope and topographic heterogeneity were important in the trees that accounted for variable interactions). Both elevation and other terrain measures are correlated with many variables that mediate plant species physiological tolerances and distribution, from climate to soil, in addition to proximity to human disturbance (Franklin 1995, Syphard et al. 2013*b*). Therefore, it is difficult to untangle the mechanism underlying this association.

Surprisingly, although there are more expansive residential development and WUI in San Diego County than in the Santa Monica Mountains, anthropogenic variables were among the lowest in percentage independent contribution, although nitrogen deposition was more important here than in the Santa Monica Mountains, perhaps due to a longer gradient inland from urban to rural. Proximity to WUI was retained as significant in the classification trees, but the variable was low on the tree and therefore not highly influential. Although proximity to development was not highly significant, there was nevertheless a substantial amount of vegetation conversion due to development (8%) or disturbance (18%), and the continuation of direct habitat loss will clearly exacerbate other fire- or disturbance-driven unintentional vegetation change.

Conclusion

This assessment of chaparral decline and replacement indicates that vegetation change is occurring extensively and rapidly in Southern California. This has serious implications for ecological and human communities, as chaparral provides critically important ecological services in the region (Underwood et al. 2018), which are not provided by exotic annual grasses and forbs. Southern California, and chaparral itself, has incredibly high biodiversity (Myers et al. 2000), with most characteristic bird, mammal, and insect communities aligning with shrub cover. Thus, the loss of chaparral is an ecological impact of global significance (Cowling et al. 1996). Further, given strong convergence in ecosystem function and structure across the world's Mediterranean regions, ongoing conversion of woody cover to herbaceous vegetation in Southern California could represent a harbinger of things to come for other regions, which are also biodiversity hotspots. In fact, increased fire frequency and feedbacks with exotic grass are already a concern in all five Mediterranean regions (Vilà et al. 2001, Pignatti et al. 2002, Milton 2004, Syphard et al. 2009). Unfortunately, due to short dispersal distances and low recruitment between fires for most chaparral and many other Mediterranean shrubland species (Keeley et al. 1989), once a stand has converted to herbaceous vegetation, reversal of this change is difficult.

Conversion of chaparral to exotic herbaceous cover may also increase wildfire risk to humans, and may lead to a perpetuating positive feedback cycle, frequently referred to as the grass–fire cycle (D'Antonio and Vitousek 1992). Positive feedbacks can occur because annual grasses and forbs are highly resilient to frequent fire, are very flammable, and typically burn in low-intensity fires that favor their persistence and a cycle of repeating fires (Keeley et al. 2012). With unprecedented recent large fires having occurred across Southern California, there are huge expanses of vulnerable young vegetation that are at risk of burning again before the minimum of at least 10–15 yr needed for chaparral recovery. Prevention and planning to reduce fire ignitions and exposure of human communities to flammable wildland, especially in these fire-saturated parts of the landscape, will be key to sustaining the future of chaparral in the region.

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Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the US government.

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EXHIBIT D

California Chaparral and Its Global Significance

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Chapter 1
California Chaparral and Its Global Significance

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Abstract Chaparral ecosystems represent the iconic vegetation of California, and in particular southern California, where it forms the dominant vegetation cover over broad areas of the foothills of the Coast, Transverse, and Peninsular ranges. Evergreen sclerophyll shrubs which makeup the characteristic component of chaparral communities parallel a similar dominance of this life-form in the Mediterranean Basin, central Chile, the Cape Region of South Africa, and Southwest Australia, regions of the world with a Mediterranean-type climate of warm dry summers and cool wet winters. The Mediterranean Biome comprised of these five regions are biodiversity hotspots that contain about one-sixth of the vascular plant species in the world in just 2.2% of the world's land area. Despite this global significance, these regions continue to be heavily impacted by urbanization, land-use change, climate change, and invasions by non-native species. Chaparral floras include not just the dominant woody shrubs but a diverse assemblage of annual and herbaceous perennial species, many of which have life histories linked to postfire succession. Fire is a natural component of the disturbance regime of chaparral and burns broad portions of the landscape in a coarse-grained manner, but with fine-grained differences in fuel composition and slope aspects. Short fire-return intervals of less than 10–15 years present an increasing threat to chaparral ecosystems by eliminating shrub regeneration and leading to type-conversion to non-native annual grasslands. Water availability and associated adaptive traits of drought tolerance are major factors in partitioning chaparral community composition. Nutrient availability is also important, as are, to a lesser extent, extremes of winter temperature. Although often maligned as a useless or even dangerous because of concerns over fire hazard, chaparral ecosystems provide critical ecosystem services through their roles in erosion control, hydrology, biomass sequestration, and preservation of biodiversity.

Keywords Chaparral · Conservation · Ecosystem services · Fire · Mediterranean-type shrublands · Phenology

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1.1 Introduction

Chaparral communities—identified by their dense evergreen cover of woody shrubs and characteristic leathery or sclerophyllous leaf structure—form the iconic vegetation of southern California, and to a lesser extent, for the entire state. Chaparral covers much of the lower elevations of the Coast Ranges and west slope of the Sierra Nevada, as well as the Transverse and Peninsular ranges of southern California Within the political boundaries of the state, chaparral makes up over 9% of the wildland vegetation (Parker et al. 2016). Half of this cover, and the largest blocks of chaparral, are located in southern California, most notably in the foothills of the Transverse and Peninsular ranges, with the largest area in San Diego County (Fig. 1.1 and Table 1.1).

Fig. 1.1 Chaparral distribution in California. This vegetation community also extends into northwestern Baja California and a small area of southern Oregon. Map from Parker et al. (2016)

Table 1.1 Chaparral areas by California county

County	Area (ha)
San Diego	404,600
Los Angeles	223,300
Riverside	201,300
Santa Barbara	177,700
San Luis Obispo	168,400
Monterey	148,900
Ventura	131,600
San Bernardino	111,300
Sab Benito	99,400
Santa Clara	76,000
Orange	45,000
Marin	15,200
San Mateo	14,600
Santa Cruz	13,000

Based on vegetation data from Fried et al. (2004)

Evergreen sclerophyll shrublands, similar to California chaparral, form the classic Mediterranean-type climate vegetation in all five regions of the world characterized by warm dry summers and cool wet winters. This weather regime, termed a Mediterranean-type climate, results from the summer movement of subtropical high pressure cells that produce dry descending air masses capping a surface marine layer of varying levels of humidity. These conditions make summer rainfall infrequent except for irregular convective thunderstorms moving in from outside of the region. Winter conditions are influenced by the polar jet stream and associated periodic storms that bring rain and snow at higher elevations. The result is a globally unusual climate regime. Mediterranean-type climate region shrublands are termed *kwongan* in Southwest Australia, *fynbos* in the Cape Region, *maquis* or *garrigue* in the Mediterranean Basin, and *matorral* in Chile. Just as chaparral forms a significant but one of many plant communities in California, each of the five Mediterranean-type climate regions support a range of other plant communities including woodlands, grasslands, and forests.

The five Mediterranean-Type Climate (MTC) regions, including California, have attracted international interest for almost 150 years as a focal point for studies of ecosystem and evolutionary convergence. This concept of convergent evolution in plant structure and function dates back to a tacit assumption of convergence in the global vegetation classification systems developed at the end of the nineteenth century (Grisebach 1872; Drude 1890; Schimper 1903). Some of these early writings were remarkably prescient in developing concepts of ecological convergence considering the limited database available. Schimper, for example, provided a broad albeit imperfect basis for understanding the adaptive significance of structural fea-

Fig. 1.2 Chamise chaparral *Adenostoma fasciculatum* on Pine Mountain, Ventura County, California. Photo by Richard Spujt

tures in shrub species and geophytes. In describing the vegetation of the five Mediterranean-type climate regions of the world, he wrote: "…the vegetation bears essentially the same stamp, in spite of deep-seated differences in composition of the flora; it is dominated by sclerophyllous plants, and always, although to a subordinate extent, by tuberous and bulbous plants."

The concept of convergent evolution suggests that comparable climatic conditions in MTCs have selected for plants with similar functional traits, resulting in analogous vegetation types that have evolved through independent evolutionary pathways (Cody and Mooney 1978; Specht and Moll 1983; Cowling et al. 1996; Keeley et al. 2012a). The similarities that are shared in the case of convergent evolution are not the result of evolution from a common ancestor, but rather are explained as shared adaptive solutions to similar environmental pressures. Textbook examples of convergent evolution include structural traits such as the multiple origins of wings in bats and birds, the morphological and physiological adaptations to aridity seen in New World cacti and African succulent euphorbias, and the evolution of functionally similar but distinct antifreeze proteins in divergent species of Antarctica and Arctic fish. Across the world's MTC regions sclerophyllous, evergreen, deep-rooted shrubs are a defining characteristic (Fig. 1.2).

Although Mediterranean-type climate ecosystems represent widely cited examples of ecological convergence, the five regions nevertheless display striking examples of divergence as well (Cody and Mooney 1978; Rundel 2011; Rundel et al. 2016). Researchers have categorized MTC regions in terms of their histories and abiotic selective regimes to help explain patterns of convergences and divergences among them. Thus, MTC regions have been differentiated in terms of climate, e.g., amount of summer rain and reliability of winter rainfall (Cowling et al. 2005), soil nutrient status (Specht and Moll 1983), fire regime (Keeley et al. 2012a), topography (Carmel and Flather 2004), and the interactions between climate, fire and soil nutrient status (Keeley et al. 2012a; Rundel et al. 2016).

1.2 Global Significance of Mediterranean-Type Climate Regions

Mediterranean-type climate regions, exemplified by chaparral, have an important place in the global biodiversity of plant species because they harbor the world's richest extra-tropical floras (Cowling et al. 1996, 2015; Kreft and Jetz 2007; Rundel et al. 2016). While this biodiversity includes plant species in woodland, grassland and forest communities, the core of this species richness and endemism resides in the evergreen sclerophyll shrublands. Outside of Mediterranean-type climate regions, evergreen sclerophyll shrublands may be widespread but are generally unexceptional in plant species diversity.

All five MTC regions have been categorized as biodiversity hotspots, i.e., regions of global significance that are home to large numbers of species and rich in endemic taxa (Myers et al. 2000). Assuming a global sum of about 300,000 vascular plant species, MTC floras comprise about one-sixth of this total despite covering only about 2.2% of the world's land area (Cowling et al. 1996). The origin of this diversity is complex and leads to a number of important questions that are relevant in understanding global patterns of species richness. Enigmatically, this high level of species richness and associated endemism is present across all spatial scales (Cowling et al. 2015) (see Chap. 2).

However, MTC regions around the world have been and continue to be heavily impacted by human activities. In a global study of the world's biomes Sala et al. (2000) estimated the mediterranean biome will experience the greatest proportional change in biodiversity by 2100 owing to its sensitivity to a suite of drivers including land use change, climate, non-native species, and nitrogen deposition. Specifically, these threats include habitat degradation and conversion, non-native species, altered fire regimes (i.e., increased fire frequencies for chaparral) and climate change. For example, in the California-Baja California Mediterranean-type climate lowlands (<300 m or 984 ft) 20% was classified as urban (1990) compared to only 2% for lowlands in the four other MTC regions (Underwood et al. 2009). As a consequence, high levels of biodiversity combined with increasing threats have made MTC regions the focal regions for conservation activities (Rundel et al. 1998).

1.3 Evolution of Chaparral Ecosystems and Diversity

To understand chaparral today, it is important to consider the evolutionary origin of this ecosystem through geological time and the origin of its remarkable biodiversity. It was once widely held that the novel Mediterranean-type climate of California and of the other four MTC regions of the world first appeared about 4–3 Ma in the Pliocene (e.g., Suc 1984; Axelrod 1989). However, there is emerging evidence that the onset of a proto-Mediterranean-type climate occurred much earlier, at least in the mid-Miocene (Rundel et al. 2016). A key event leading to the onset of global Mediterranean-type climate regimes was the end of the Middle Miocene Climate Optimum 17–14 Ma, associated with global cooling and growth of the East Antarctic ice sheet. Atmospheric and oceanic circumpolar circulation intensified during this period, resulting in increased strength of the Hadley Cell, ocean current circulation, and seasonal movement of the subtropical high pressure centers, thereby promoting conditions favorable for a Mediterranean-climate formation. More speculatively, there may have been periods of Mediterranean-type climate formation even earlier contemporaneously with Antarctic glaciation in the Oligocene (Rundel et al. 2016). Although the global patterns of atmospheric circulation that determine this climate regime are clear, the seasonal intensity of Mediterranean-type climate has likely varied through time. Changing offshore ocean currents influence the nature of these regimes, with cold currents intensifying summer drought, and warm currents increasing summer rainfall.

The chaparral flora today includes a number of paleo-endemic taxa that predate the development of a Mediterranean-type climate regime, for example Fabaceae (*Pickeringia*), Rosaceae (*Adenostoma*), Cactaceae (*Bergerocactus*), Rutaceae (*Cneoridium*), Papaveraceae (*Dendromecon*), Anacardiaceae (*Malosma*), and Hydrangeaceae (*Carpenteria*). However, none of these genera has undergone significant speciation and collectively form only a small part of chaparral species richness. A similar pattern of floristic assembly is present in the relatively young and dynamic landscapes of the Mediterranean Basin and central Chile where a limited number of paleo-endemic sclerophyll shrubland lineages have persisted while adding little to floristic diversity. In contrast, Southwest Australia and the Cape Region, with their relatively quiet geomorphic and climatic histories through the Cenozoic, exhibit many highly diverse woody plant lineages that have ancient origins in evergreen sclerophyll shrublands on oligotrophic soils as early as the Upper Cretaceous—early Cenozoic (Lamont and He 2012).

For California, the development of the modern chaparral flora is associated with immigration and diversification from a large regional species pool. This occurred under the influence of a novel climatic seasonality and predictable crown fire regimes associated with the development of a Mediterranean-type climate regime in the Miocene. In addition to the evolution of key life history strategies to cope with fire, other ecological factors not unique to Mediterranean-type climate regions have contributed to species diversity. These include adaptations to diverse spatial patterns of climatic, topographic, and edaphic heterogeneity during the

Pliocene and Quaternary. Much of this endemic diversification has been centered on annual plants and herbaceous perennials in clades within such families as the Asteraceae, Boraginaceae, Brassicaceae, Fabaceae, Lamiaceae, Onagraceae, Polemoniaceae, and Polygonaceae. Only two genera of woody chaparral shrubs exhibit extensive diversification: *Arctostaphylos* (Ericaceae; Boykin et al. 2005) and *Ceanothus* (Rhamnaceae; Burge et al. 2011). This pattern contrasts with evolution of the Mediterranean-type climate ecosystem floras of the Cape region and Southwestern Australia where many woody plant lineages have diversified into large genera (Rundel et al. 2016).

1.4 Chaparral Vegetation Structure and Classification

Much of the rich diversity of chaparral communities is hidden by the closed canopy structure that makes individual species difficult to discern at a distance for much of the year. The most widespread and characteristic species exemplifying chaparral is chamise (*Adenostoma fasciculatum*) which often forms virtual monocultures on dry south-facing slopes or rocky areas with shallow soils (Keeley and Davis 2007, Fig. 1.3). Chamise chaparral extends over the entire range of the biome in California and south into Baja California. Less xeric north-facing slopes or those with deeper soils are often simply termed mixed chaparral with a diverse assemblage of species sharing dominance (Fig. 1.3). The most common co-dominant species are scrub oak (*Quercus berberidifolia*) and species of ceanothus (*Ceanothus* spp.) and manzanita (*Arctostaphylos* spp.), the two largest genera of chaparral shrubs, with 46 and 61 species, respectively, and many local endemics. Some coastal areas of chaparral may be dominated by a single and often locally endemic species of *Ceanothus* or *Arctostaphylos*.

Looking at the life-forms of plant species growing within chaparral, woody shrubs comprise only about 19% of the flora, with annuals and herbaceous perennials forming 35% and 39% of the flora, respectively (Table 1.2; Halsey and Keeley 2016). This breakdown of life-forms is proportionally far richer in shrub species than the flora of the entire California Floristic Province and lower in proportional richness of herbaceous perennials. Chaparral shrub species are high in endemics and contain many species listed as rare, endangered, and threatened (Fig. 1.4).

However, the rich diversity of dominant or co-dominant shrub species that may be present across even relatively small landscape gradients (Moody and Meentemeyer 2001) has led to classification systems based solely on these dominants. One of the first attempts to define vegetation units of chaparral at a broad scale was a top-down approach (Holland 1977; Holland and Keil 1989) who separated 11 different chaparral community types. Six of these types were recognized by dominant species *Adenostoma fasciculatum*, redshank (*Adenostoma sparsifolium*), *Arctostaphylos* spp., *Ceanothus* spp., *Quercus berberidifolia*, and mixed chaparral), four geographically distinct forms which they termed maritime, Channel Island, montane, and semi-desert, and one edaphic form as serpentine chaparral. Further refining a classification

Fig. 1.3 Slope impact on community structure in the Santa Monica Mountains of Los Angeles County. Photo shows mixed chaparral with dominance of hoaryleaf ceanothus (*Ceanothus crassifolius*) on north-facing slopes and coastal sage scrub on drier south-facing slopes. Photo by Noah Elhardt

Table 1.2 The life-form distribution of the chaparral flora compared to the total California flora

Life-form	California native flora	Relative %	Chaparral species	Relative %
Annual herb	1469	30	415	35
Perennial herb	2524	52	460	39
Shrub	599	12	228	19
Tree	84	2	22	2
Others	170	4	52	4
Total	4846		1177	

Adapted from Halsey and Keeley (2016)

system, R.F. Holland (1986) divided chaparral further by identifying 44 different community types. This work generally followed V.L. Holland's original terminology but with further specific refinements, as with the division of maritime chaparral into northern, central, and southern forms, and adding edaphic controls. *Ceanothus* and *Arctostaphylos* chaparral communities were further divided on the basis of dominant species. Most recently, Sawyer et al. (2009) have adopted an approach for California from the national hierarchical vegetation classification system in which chaparral alliances are defined by one or two dominant species as well as a number of associations within alliances based on semi-quantitative plot measurements. The result is more than 60 classified alliances of chaparral vegetation, and many more associa-

Fig. 1.4 Old-growth chaparral dominated by mission manzanita (*Xylococcus bicolor*) in San Diego County, California. Photo by Richard Halsey

tions. Although this system of classification has a practical value as a naming system for resource management and environmental impact studies, it provides little ecological insight into habitat conditions because of the independent distribution of individual chaparral species (Zedler 1997).

1.5 Chaparral Geography

Chaparral is widely distributed across California, with its typical occurrence in the foothills of the Coast Ranges and Sierra Nevada. The upper elevational distribution of chaparral ranges from about 800–1200 m (2625–3937 ft) in the northern Sierra Nevada and 1400–1600 m (4593–5249 ft) in the southern Sierran foothills as well as the Transverse and Peninsular ranges. Above this foothill zone, these communities are replaced by ponderosa pine forest and mixed conifer forest. At higher elevations within the lower and upper montane zones, local stands of montane chaparral occur in azonal conditions associated with shallow soils, serpentine substrates, and/or postfire successional sequences. In this latter case, these stands may have long-term persistence as a consequence of self-reinforcing, high-intensity wildfires. Montane chaparral stands may include high-elevation species of *Ceanothus* and *Arctostaphylos*, but overall the shrub flora is distinct from foothill chaparral, and indicator genera like *Adenostoma*, *Pickeringia, Garrya* (Garryaceae), *Rhamnus* (Rhamnaceae), and *Heteromeles* (Rosaceae) are absent.

North of San Francisco the distribution of chaparral becomes more restricted, moving inland and progressively dropping in its cover and exhibiting reduced diversity. On more mesic sites, chaparral is replaced by an evergreen sclerophyllous woodland of temperate affinity, dominated by the evergreen tanbark oak (*Notholithocarpus densiflorus*), California bay (*Umbellularia californica*), madrone (*Arbutus menziesii*), and Douglas fir (*Pseudotsuga menziesii*) along with the winter deciduous black oak (*Quercus kelloggii*). A few elements of chaparral extend into the Rogue River basin in Oregon.

Transitions from chaparral to other vegetation associations in southern California occur with abiotic changes in water availability, temperature extremes, soil type, and aspect and elevation that impact these factors. At its drier margin along the coastal areas below about 300 m (984 ft), chaparral is commonly replaced by a drought deciduous community termed sage scrub. Sage scrub species are characteristically semi-woody and lose their leaves with the onset of summer drought, and flushing new leaves after fall rains (Rundel 2007). In addition, the shallow-rooted sage scrub dominants typically do not resprout, or resprout poorly following fire, and lack soil seed pools (Rundel 2007). Many of these sage scrub species do well at higher elevations in the chaparral zone on areas of landslides or other disturbances that restrict establishment of long-lived chaparral shrubs. However, they are shaded out by larger and longer lived evergreen chaparral shrubs when facing competition from them. A similar but less species-rich sage scrub community replaces chaparral at its drier inland margin where it grades gradually into desert associations.

Within the chaparral zone itself, valley oak (*Quercus lobata*) woodlands replace chaparral in valley bottoms with deep soils in the Coast Ranges. Depending on soil depth and exposure, many of the foothill areas of the Coast Ranges exhibit mosaics of chaparral, blue oak (*Quercus douglasii*) woodland, and open non-native annual grassland. In the foothills of the Sierra Nevada, mosaics exist with *Adenostoma fasciculatum* on shallow rocky soils, *Quercus douglasii* woodland on deeper soils with fractured substrate allowing deep root penetration, and mixed evergreen woodlands co-dominated by the evergreen interior live oak (*Quercus wislizenii*), mountain mahogany (*Cercocarpus betuloides*), foothill pine (*Pinus sabiniana*), and California buckeye (*Aesculus californica*). Where there are steep transitions to Mojave or Sonoran Desert habitats, a desert-chaparral ecotone is present with a mix of shrub species from both biomes, including shrubby evergreen oaks.

To the south, chaparral continues into northwest Baja California, and with small disjunct populations of a subset of species on mountain slopes as far south on the peninsula as 28°N. In addition, elements of chaparral species and communities extend eastward from southern California across the higher elevations of the Mojave Desert into upland areas of northern Arizona (Fig. 1.5). These landscapes are most apparent on the slopes of the Mogollon Rim in the middle of Arizona (Knipe et al. 1979), a region with a bi-seasonal pattern of precipitation. Similar stands can be seen in northern Mexico in Nuevo León in a region with a summer rainfall regime and dry winters (Vankat 1989; Keeley et al. 2012a) (Fig. 1.6).

Fig. 1.5 Chaparral in Prescott National Forest, Arizona, USA. Photo by Alan Stark

Fig. 1.6 Broad generalized distribution of chaparral in North America. Adapted from Rundel and Vankat (1989)

1.6 Chaparral and Fire

Fire is a natural component of the disturbance regime of chaparral. Mature shrublands typically range from 1 to 5 m in height and form a dense closed canopy that excludes most herbaceous surface fuels. As stands age, a substantial amount of dead branch tissue is maintained in the canopy, providing a fuel structure that reinforces the crown-fire regime where combustion spreads through the canopies with relatively little surface fire. These chaparral fires burn broad portions of the landscape in a rather coarse-grained manner, although there are fine-grained differences in plant associations on different slope aspects. Natural fire-return intervals in chaparral are not well known because of the absence of records to measure fire frequency before the advent of humans in California. In any case, the natural return interval in fire regimes clearly varies greatly across the state, from as often as 30 years in areas of northern California with frequent lightning activity to 100 years or more in coastal southern California where natural sources of ignition are rare (Van de Water and Safford 2011). Historical fire records for chaparral landscapes in southern California indicate fires have increased in number since the 1930s (Safford 2007), and some locations in southern California are experiencing such frequent fire that chaparral has transitioned to weedy grassland. Almost all of these excess ignitions relate to unintentional or deliberate human activities (Syphard et al. 2007) (Fig. 1.7).

Fig. 1.7 Maritime chaparral with prescribed management burn at Fort Ord, Monterey County, California. Photo by US Army Corps of Engineers

During the first spring following fire on most sites with moderate fertility, a postfire flora of annuals and herbaceous perennials develop as the first stage of postfire recovery. Many of these are fire-following annuals with germination from soil seed pools stimulated by chemical cues within the ash of the fire. This ephemeral flora produces a significant load of fine fuels that help to reduce erosion and stabilize soil nutrient pools (Rundel and Parsons 1984). It is noteworthy that in areas where moderate fire intensities have left blackened skeletons of chaparral shrubs, this dead material plus dried ephemeral vegetation can contain significant fuel loads often in excess of 10 ton ha^{-1} only a year after fire (Keeley et al. 2012b). Non-native annual grasses can also enhance this impact. The fine fuels are easily ignited and are sufficient to carry fire in very young stands, which can be highly detrimental to the recovery of many of the prefire shrub dominants.

The postfire recovery of chaparral shrubs takes place either through resprouting from under-ground root crowns or alternatively from germination of obligate seeding species from soil seed pools (see Chap. 2). The great majority of chaparral shrubs re-establish their canopy dominance by resprouting. For many of these species there are no soil seed pools and they recruit seedlings during fire-free intervals. Such shrub species include *Quercus berberidifolia*, hollyleaf redberry (*Rhamnus ilicifolia*), lemonade berry (*Rhus integrifolia*), toyon (*Heteromeles arbutifolia*), holly-leaved cherry (*Prunus ilicifolia*), and laurel sumac (*Malosma laurina*). Seedlings of these species have a relatively high degree of shade tolerance, and exhibit a similar or greater water stress tolerance to the facultative seeders, suggesting they face strong competition for soil water in mature chaparral (Pratt et al. 2008). Other resprouters are facultative seeders which recruit seedlings in open microsites but have greater survival where drought and shade stress are reduced. Chaparral shrubs with obligate seeding strategies where parent plants are killed by fire are largely restricted to the genera *Arctostaphylos* and *Ceanothus* which exhibit both resprouting and obligate seeding strategies (Pratt et al. 2008). Consistent with the open postfire habitats where seedlings become established, seedlings are tolerant of water stress and intolerant of shade. An intermediate situation is present in *Adenostoma fasciculatum*, which is an active resprouter but additionally exhibits fire-stimulated seedling establishment from relatively short-lived soil seed pools (Stohlgren et al. 1984; Rundel et al. 1987).

Typically, chaparral shrub canopies recover and close up within 10 years following fire, after which the ephemeral flora persists in dormant soil seedbanks. Over the subsequent decade, shrub canopies expand and the ratio of live to dead fuel remains high. The relationship between stand age and live/dead ratio may be an important determinant of flammability under all but the most extreme conditions. As a consequence of structural difference in successional stages, chaparral communities go through a change from being highly vulnerable to fires during the first 5 years because of herbaceous flash fuels, then reduced susceptibility for a decade or two until dead fuels accumulate in the shrub canopies (Schoenberg et al. 2003). However, chaparral stands of any age become highly flammable under conditions of low relative humidity, drought stress, and high temperatures, as are associated with Santa Ana wind conditions in southern California.

Landscape patterns of chaparral distribution can significantly affect chaparral fire regimes (Keeley et al. 2009). Chaparral shrublands dominate a decreasing proportion of the landscape moving from south to north in California, and thus is seems unsurprising that chaparral fires tend to be the largest in the southern half of the state. Even within this region there are marked differences in fuel patterns that affect fire size (Keeley and Zedler 2009). Many of the largest fires (>50,000 ha or 123,552 acres) have occurred either in San Diego County or further north in Santa Barbara/ Ventura counties where the topography supports large contiguous east-west swaths of shrubland fuels and where strong offshore and onshore wind flows can drive fire over very long distances.

1.7 Chaparral Phenology

Most chaparral shrubs use an ecophysiological strategy based on evergreen leaves that are able to photosynthesize throughout the year in the relatively moderate climate in which they grow. They typically exhibit a broad range of optimal temperature for photosynthesis, which allows for moderate rates of carbon fixation even under winter conditions (Oechel et al. 1981; Mooney and Miller 1985). However, a general trade-off in having thick sclerophyllous leaves is that maximum rates of net assimilation are relatively low compared to those of thinner and less leathery leaf structure. During the dry summer and autumn months, as water becomes less available, most chaparral shrubs reduce their rates of carbon fixation by stomatal control, to reduce loss of water through transpiration.

While chaparral shrubs are characterized by having the functional trait of evergreen sclerophyllous leaves—in contrast to the drought deciduous leaves that characterize sage scrub dominants—leafing phenology is more complex. Evergreenness is not a simple trait but instead comes with multiple forms of leaf retention and levels of sclerophylly. The classic chaparral shrub maintains 2 years of leaves, as with most evergreen species of *Quercus, Adenostoma,* and *Arctostaphylos*, shedding the older set soon after or at the same time as new leaves are formed in spring. Many species of *Rhamnus* and *Ceanothus*, however, retain leaves for only 13–15 months, retaining only a single cohort of leaves for most of the year. At the other extreme, some chaparral shrubs such as *Heteromeles arbutifolia*, and the coastal *Malosma laurina* and *Rhus integrifolia* may retain leaves for 4–6 years (Field et al. 1983; Sharifi and Rundel unpublished data). A small but significant number of chaparral shrubs exhibit winter deciduous behavior, including chaparral ash (*Fraxinus dipetala*) and many species of *Ribes* (golden currant [*R. indecorum*] and chaparral currant [*R. malvaceum*]). Coastal areas of northwestern Baja California have chaparral-like stands of maritime scrub dominated by deciduous shrubs of lower California buckeye (*Aesculus parryi*), Baja California hop tree (*Ptelea aptera*), and *Fraxinus dipetala* (Fig. 1.8). This is a trait widely present in riparian tree species within chaparral dominated landscapes, such as willows (*Salix*), western sycamore (*Platanus racemosa*), and white alder (*Alnus rhombifolia*) where it reflects a temperate forest ancestry.

The vegetative growth of chaparral shrubs is influenced by a variety of abiotic and biotic factors, with available soil moisture, temperature, and photoperiod as the most important factors. The Mediterranean-type climate presents strong challenges as soil moisture is most available in the winter months when temperatures are lower than those optimal for growth, while favorable warm summer temperatures occur in summer when drought conditions prevail (Davis and Mooney 1986). It is not surprising, then, that the peak growing season for most shrubs is in spring, when temperatures and photoperiod rise and soils are still moist (Mooney et al. 1977).

Flowering phenology in chaparral shrubs peaks in this same spring season for many species but is highly variable depending on a variety of factors including the phylogenetic lineages of the species. A number of species flower in winter or very early spring from preformed buds set in the previous growing season on mature stems. This form of flowering can be best seen in species of *Ceanothus, Arctostaphylos*, and *Ribes*. At the other extreme are species such as *Adenostoma sparsifolium* that flower in mid-summer.

1.8 Water Availability and Drought Tolerance

Because a protracted summer dry season of 4–6 months is characteristic of chaparral habitats, morphological traits of rooting architecture and ecophysiological traits of water use efficiency and drought tolerance are important for survival of chaparral shrubs and for the establishment of seedlings (Mooney 1989). In addition, much of the range of chaparral experiences high summer temperatures and solar irradiance that far exceeds the plant's ability to use this energy for photosynthesis. Water availability is to a major degree a function of soil depth, but slope aspect, substrate geology, and local hydrology may also have major influences on its availability to chaparral shrubs. While it seems intuitive that arid south-facing chaparral slopes would experience the longest periods of soil moisture stress, this is commonly not the case. The lower leaf area index and low rates of transpiration from drought tolerant shrub species compared to more mesic north-facing slopes means that soil moisture stress may occur earlier on these north-facing slopes (Ng and Miller 1980). Areas along the coast influenced by the upwelling and the cold California Current have some mitigation of the summer dry season due to fog occurrence which may provide additional moisture but also conditions which reduce transpiration (Vasey et al. 2012). Along the central California coast and in areas of northwestern Baja California these conditions may promote the development of a distinctive maritime chaparral. However, the southern California coast largely lacks regular fog and provides few opportunities for the development of such communities.

Chaparral shrubs have been categorized along a continuum by the degree of water availability that they experience during the summer dry season, as measured as the minimum seasonal water potential (Davis and Mooney 1986; Bhaskar and

Fig. 1.8 Maritime chaparral with coastal sage scrub at Torrey Pines State Park, San Diego County, California. Photo by User Nauticashades

Ackerly 2006). At one end of the continuum are shallow-rooted species that experience low water potentials as surface soils dry. Good examples of this morphology is exemplified by *Ceanothus* species in the subgenus *Cerastes* and shrubby species of drought deciduous *Salvia* such as black sage (*S. mellifera*) (Thomas and Davis 1989; Jacobsen et al. 2007). These drought tolerators typically exhibit hydraulic traits in their xylem system that restrict the formation of embolisms and allow them to survive extremely low water potentials (Venturas et al. 2016). At the other end of the continuum are deep-rooted shrubs that avoid water stress by tapping subsurface pools of water. This group is exemplified by Anacardiaceae of subtropical ancestry including *Malosma laurina*, sugar bush (*Rhus ovata*), and *Rhus integrifolia* (Thomas and Davis 1989; Jacobsen et al. 2007). Most chaparral shrubs experience water potentials between these two extremes of drought tolerators and avoiders, generally suggesting intermediate rooting depths.

Species tolerant of low water potentials typically exhibit a suite of traits that allow them to maintain a broader range of physiological function at more negative water potentials. Key among these is greater resistance to water stress-induced xylem cavitation, caused by air bubbles pulled into xylem conduits where they embolism (Kolb and Davis 1994; Davis et al. 1998, 2002). Species that experience more negative minimum seasonal water potentials have greater cavitation resistance (Davis et al. 1998, 1999a, b; Jacobsen et al. 2007; Pratt et al. 2007). As a group, evergreen chaparral shrubs typically have greater cavitation resistance in their stems compared to deciduous shrubs that occur in the chaparral community. As might be expected, greater cavitation resistance is correlated with increased survival of drought in chaparral seedlings (Pratt et al. 2008).

1.9 Temperature Limitations

Although extremes of winter temperatures across the range of chaparral distribution are relatively mild by temperate standards, these regions can intermittently experience periods of very low winter temperatures. Extremes of winter lows may reach −8 °C to −12 °C every few years, even in the Coast Ranges of southern California. Some chaparral shrubs are susceptible to freezing injury caused by xylem embolism, and this sensitivity may limit their distribution (Langan et al. 1997; Davis et al. 1999a, b). The best examples of cold tolerance as a limiting factor in the distribution of chaparral shrubs can be seen in taxa of tropical ancestry, as with members of the Anacardiaceae such as *Malosma laurina* and *Rhus integrifolia*, which are restricted to coastal foothill areas of southern California and Baja California. Low temperature tolerance has been shown to vary among chaparral species as well as between adult shrubs and seedlings in the ability of their leaves to acclimate (Boorse et al. 1998).

1.10 Nutrient Availability

In addition to water availability, soil nutrients may also be an important limiting factor for growth of chaparral shrubs. Young and relatively skeletal soils that characterize much of the chaparral region of California are often low in nitrogen, leading to adaptive strategies to minimize loss of nitrogen and other nutrients as leaves senesce. Indeed, the evergreen habitat is often associated with plant species growing on low nutrient soils, and has been widely suggested as an adaptation to increase the efficiency of nutrient utilization (Rundel 1982). The dynamics of nutrient cycling has been studied in some detail in *Adenostoma fasciculatum*, a species that serves as a model for other chaparral shrubs. Seasonal changes in the nitrogen and phosphorus content of leaf tissues indicate that the plant takes up nutrients during the winter rainy season prior to the initiation of above-ground vegetative growth (Mooney and Rundel 1979). This seasonality of uptake allows a sustainable conservation of key nutrients that would otherwise be lost as decomposition and leaching occur during the wet winter season, with the evergreen leaves providing a sink for nutrient retention during these periods without above-ground growth.

Periodic fire in chaparral ecosystems has an important impact on nutrient cycling with a temporal cycle of change which involves the initial loss of nutrients that were previously held in the above-ground biomass, litter, and surface soils (Christensen and Muller 1975; DeBano and Conrad 1978; Rundel and Parsons 1980). This fire-induced change in the relative distribution and abundance of nutrients is of significance to the entire biotic community. For example, the relative availability of nutrients in the soil determines plant growth, while foliar nutrient contents determine the suitability and attractiveness of the foliage as browse for grazing animals. Burning produces very profound effects on nutrient cycles by rapidly mineralizing above-ground biomass and litter into ash. Changes in available forms of nitrogen and increased microbial activity following fire provide important means of promoting favorable nutrient conditions for new growth. A significant initial increase in soil concentrations of ammonium and organic nitrogen is well documented in the first weeks following fire (Christensen 1973). The ammonium is quickly mineralized, resulting in the commonly observed high nitrate concentrations in recently burned areas. These high nitrate levels, together with increases in phosphorous, organic nutrients, and selected mineral elements during the first 18 months following fire (Christensen and Muller 1975), create a highly favorable condition for a postfire flush of herbaceous species as well as shrub growth during the first few years following a chaparral fire.

Hot chaparral fires volatilize significant amounts of nitrogen from above-ground biomass, litter and surface soils, and this nitrogen is lost to the atmosphere. Studies reviewed by Rundel and Vankat (1989) found a fire loss of 119–241 kg ha^{-1} of nitrogen from *Adenostoma* stands, amounting to as much as 7% or more of total system nitrogen. Further losses of nitrogen on the order of 8–15 kg ha^{-1} can occur through erosion and runoff (DeBano and Conrad 1978). The rapid establishment of postfire annual species forms the major biomass pool in the first spring and often second year after fire, and plays an important ecosystem role in sequestering nutrients that might otherwise be loss through erosion and leaching (Rundel and Parsons 1984). Chronosequence studies of chamise chaparral have shown that these substantial losses of nitrogen are replaced within 5–10 years after fire through a variety of inputs. The primary source of this nitrogen comes from the legume subshrub deerweed (*Acmispon glaber*, formerly known as *Lotus scoparius*). This species widely germinates in large numbers from soil seedbanks following chaparral fires and fixes 10–15 kg ha^{-1} $year^{-1}$ (Nilsen and Schlesinger 1981). A second source of nitrogen input comes from dry deposition associated with atmospheric aerosols. This input has been estimated to be about 1–2 kg ha^{-1} $year^{-1}$ in pristine areas of chaparral (Schlesinger and Hasey 1980) and up to 15 times this amount in polluted air masses associated with chaparral stands in the foothills of the Transverse Ranges (Riggan et al. 1985).

A number of woody chaparral shrubs have the ability to form symbiotic associations with nitrogen-fixing bacteria, but the significance of inputs of symbiotic nitrogen fixation for mature chaparral stands is not well established. The genus *Ceanothus* is well known for its potential to fix significant amounts of atmospheric nitrogen in moist forest environments in the western United States, but does not appear to have a significant impact on soil nitrogen pools in chaparral (Pratt et al. 1997). Another widespread chaparral shrub with symbiotic nitrogen fixation is *Cercocarpus betuloides*. Stands of *Cercocarpus* in the Great Basin actively fix nitrogen (Lepper and Fleschner 1977). Nitrogen fixation is also known to occur in chaparral pea

(*Pickeringia montana*), the only native woody legume shrub present in chaparral, and in mountain misery (*Chamaebatia foliolosa*) and southern mountain misery (*C. australis*) (Rundel et al. 1981).

1.11 Ecosystem Services Provided by Chaparral

Chaparral has often been described with such words as useless, dense, and impenetrable, and is often maligned as dangerous because of its flammability (see Chaps. 5 and 12). Such misconceptions too often lead to irrational public policy that promotes destructive land management practices to eliminate chaparral through broad scale removal of native shrublands through burning, mastication, and herbicide treatments. However, both historically and continuing today, chaparral ecosystems provide a variety of significant ecosystem services (see Chapters 2, 3, 4, 6, 7, 8, 9 and 11). Ecosystem services describe the ways that ecosystems directly or indirectly provide a positive benefit to people. Such services can be categorized as regulating (e.g. climate amelioration, flood control), provisioning (e.g., food, fuel, fresh water), supporting (e.g. nutrient cycling and carbon sequestration), and cultural (e.g., aesthetic, educational, recreation) (Millennium Ecosystem Assessment 2005).

The growth of chaparral cover on steep hillsides helps to reduce flooding, erosion, and mudslides that can occur during winter rains (Gabet and Dunne 2002) (see Chap. 7). This service is especially apparent after chaparral crowns have been removed by intense crown fire, and heavy winter storms cause costly and lethal mudslides (Ren et al. 2011). A second regulating service comes with the energy balance as chaparral absorbs sunlight and transpires water, thereby helping to regulate temperature during the hot summer months compared to highly urbanized areas that experience the "heat island effect" (LaDochy et al. 2007).

Provisioning services of chaparral center on filtration of water, which helps to maintain fresh drinking water in aquifers and reduce eutrophication in the ocean and reservoirs that receive runoff (see Chap. 8). This is important in areas of southern California where nitrogen deposition from air pollution is high and nitrate is prone to leach into groundwater and collect in downstream bodies of water. Watersheds of the San Bernardino and San Gabriel mountains northeast of Los Angeles exhibit some of the highest levels of nitrogen pollution in the United States (Fenn and Poth 1999). Areas that were formerly chaparral and now converted to grassland have been shown to be less effective at filtering water and yield greater nitrate runoff (Riggan et al. 1985). Moreover, chaparral ecosystems also provide critical food and habitat resources for a diversity of native animal species and help to stabilize trophic chains.

Supporting services provided by chaparral include a significant role in carbon sequestration with stands of chaparral (see Chap. 6). Mature stands of chaparral can support 40–80 tons ha^{-1} or more of above-ground biomass (Rundel and Vankat 1989). Because chaparral stands continue to maintain high rates of productivity with age, even old stands remain significant carbon sinks (Luo et al. 2007). These large amounts of carbon biomass have led to suggestions that chaparral could be harvested on a sustainable basis to provide biofuel for the generation of electricity (Riggan and Dunn 1981). Experimental type-conversion of chaparral slopes to grassland to increase water yield has also been attempted in the past (Hill and Rice 1963; Meixner and Wohlgemuth 2003). The results indeed decreased transpirational water loss from the deeply-rooted chaparral canopies, but came at the expense of landscape instability, reduction in water quality, reduction in temperature regulation associated with canopy energy balance, and loss of wildlife value.

There has been an increasing realization in recent years of the significance that chaparral communities play in providing pollination services for adjacent agricultural developments. The pollination services provided by native bees are associated with the amount of nearby natural habitat where these bees reside (Kremen et al. 2004).

Although less easy to quantify, chaparral habitats provide significant cultural services in the role they play for outdoor recreation (see Chap. 10). These activities are particularly significant in and around the large urban areas of southern California where millions of visitors enjoy hiking, biking, horseback riding, and camping. Many families, including many from minority communities in inner cities, flock to picnic areas of local parks and reserves on weekends and holidays.

1.12 Chaparral Conservation in an Era of Global Change

Despite the significant role that chaparral shrublands play in providing ecosystem services and as hotspots of biodiversity, informed management of California chaparral ecosystems has often been neglected (see Chap. 15). Nevertheless, chaparral ecosystems remain disproportionately vulnerable to major global threats to sustainability and biodiversity. These threats can be best mitigated when local, state, and federal agencies coordinate their activities to utilize the best available science and adaptive management practices.

Across the state of California there are over 6,000,000 ha (~15,000,000 acres) of shrublands, accounting for almost 15% of the landscape, but management authority is split between multiple federal, state, and local agencies. The largest areas are managed by the USDA Forest Service, with 40%, and the Bureau of Land Management with 15% of the area (Table 1.3). About one-third (31%) of shrubland is under private ownership. All other organizations, such as the National Park Service and California Department of Parks and Recreation, each manage <2.5% of the shrubland in the state.

Global change models predict that the climate of California will be increasingly warmer and, at least for southern California, drier in the coming decades (Hayhoe et al. 2004; Neelin et al. 2013) (see Chap. 14). These changes will impact chaparral ecosystems in a number of ways, with complex interactions between temperature means and extremes, precipitation amounts and seasonality, and local soil moisture storage capacities. It has been suggested that increasing CO_2 associated with global change may increase water-use efficiency and alter patterns of fuel moisture in ways

Table 1.3 Ownership of shrubland in the state of California. Shrubland data are derived from the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program vegetation data (FRAP 2015) and the California Protected Areas Database (version 2014a)

	Area (ha)	Area (acres)	Percent (%)
USDA Forest Service	2,458,600	6,075,309	40.45
Private	1,887,200	4,663,354	31.05
Bureau of Land Management	952,400	2,353,422	15.67
National Park Service	150,000	370,657	2.47
Department of Defense	147,900	365,467	2.43
Local Government	142,800	352,865	2.35
CA Dept. of Parks and Recreation	95,500	235,985	1.57
Bureau of Indian Affairs	72,800	179,892	1.2
CA Dept. of Fish and Wildlife	59,800	147,768	0.98
Non-Profit Conservancies and Trusts	57,300	141,591	0.94
Other State Lands	27,200	67,212	0.45
US Fish and Wildlife Service	10,200	25,205	0.17
Other Federal Lands	7900	19,521	0.13
Bureau of Reclamation	6400	15,815	0.1
CA Dept. of Forestry and Fire Protection	1500	3707	0.03

that potentially could offset increasing fire hazard due to warmer temperatures (Oechel et al. 1995). However there are secondary effects that may negate this advantage. Increased atmospheric CO_2 under future climates will also stimulate biomass accumulation and influence high-intensity fires. Increased CO_2 may well have unexplored and unanticipated impacts on soil microbial communities with associated changes in the dynamics of litter decomposition and nutrient cycling, with cascading effects across food webs (Oechel et al. 1995).

A significant indirect impact of climate change on chaparral may well come through changes in fire regime. Chaparral stands are generally not resilient to fire-return intervals less than about 10–15 years (Keeley et al. 2012b), and the increased number and frequency of anthropogenic ignitions in southern California have already led to major areas of type-conversion from chaparral to non-native annual grassland (see Chaps. 12 and 13). Once converted, an alternate stable state may be reached where ignitions can occur almost any time of the year because of the fine grass fuels. This said, land-use changes from urbanization and agricultural development over the coming decades may well play as important or more important a role as climate change in the conservation of chaparral and related shrubland ecosystems (Riordan and Rundel 2014).

Historically the primary management focus on chaparral, particularly in southern California, has been on management of fuels and fire hazard, with little emphasis on the sustainability of chaparral ecosystems and the associated ecosystem services provided. In simple terms, chaparral has been widely ignored by federal and state management agencies as an uninteresting but flammable landscape that produces threats to the built environment of California. One example of this lack of interest can be seen in the history of management plans for the national forests in southern California. Unlike other units of the national forest system, the Angeles, Cleveland, San Bernardino, and Los Padres national forests were originally set aside to protect watershed values rather than manage timber resources. Although important communities of conifers are present, chaparral ecosystems characterize a major component of their landscape. The dominance of chaparral over timber makes these four national forests distinct from any other forest units in the federal system. However, for a variety of historical and cultural reasons that fail to value chaparral like a commodity, land managers have neither given adequate attention to chaparral as an important natural resource nor appreciated its ecological and ecosystem value. As a result, chaparral has been treated more as a fuel problem than a native plant community worthy of preservation, and chaparral management plans have largely ignored sustainability and ecosystem services, and have centered instead on approaches to fuel reduction.

Today there is an increasing understanding at many government levels that chaparral ecosystems provide critical ecosystem services, most directly through their role in erosion control, hydrology, biomass sequestration, and preservation of biodiversity. These functions will increase in significance in the future under conditions of reduced precipitation and warmer temperatures. The presence of chaparral communities at or near the expanding boundaries of suburban development leads to inevitable conflicts between the impacts of chaparral wildfire and the protection of human life and structures. Such conflicts will continue without informed regional and local policies for planning and land use development.

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