



T 510.836.4200  
F 510.836.4205

1939 Harrison Street, Ste. 150  
Oakland, CA 94612

www.lozeaudrury.com  
michael@lozeaudrury.com

August 3, 2020

Ben Blom, Field Manager  
Erik Zaborsky, Assistant Field Manager  
BLM Central Coast Field Office  
Attn: Cotoni-Coast Dairies RMPA/EA  
940 2nd Ave., Marina, CA  
93933-6009  
blm\_ca\_cotoni\_coast\_dairies@blm.gov

Re: Cotoni-Coast Dairies, a Portion of the California Coastal National Monument  
Draft Resource Management Plan Amendment and Environmental Assessment –  
Friends of the North Coast Supplemental Comments

Dear Messrs. Blom and Zaborsky,

On behalf of Friends of the North Coast (“FONC”), I am submitting the following supplemental comments regarding the Bureau of Land Management’s (“BLM”) Draft Resource Management Plan Amendment and Environmental Assessment (“EA”) prepared for the Cotoni-Coast Dairies portion (“Monument”) of the California Coastal National Monument. The purpose of these supplemental comments is to provide additional information to BLM regarding the significant problems created by BLM’s possible adoption of access facilities at the Marina Ranch Gate Road and the significant adverse impacts that proposal would have on one of the most scenic and sweeping vistas within the Monument. The preservation of this and other beautiful vistas within the Monument is integral to BLM meeting its obligations to craft a management plan that achieves the purposes of Presidential Proclamation 9563. Such visual resource preservation is also necessary to achieve the required consistency with the California Coastal Act.

In addition, significant new information has arisen since the deadline for submitting comments. A robust scientific compendium of current studies identifying wildlife impacts from non-consumptive recreational activities, such as those that will be allowed in the monument, was published by the California Department of Fish & Wildlife. Also significant is the recent decision on June 3, 2020 of the Ninth Circuit Court of Appeals vacating the registration of the herbicide dicamba, one of the key herbicides BLM was intending to rely upon to treat invasive broad leaf plants.

It appears from its e-mail earlier today that BLM has decided to proceed with an environmental assessment rather than an environmental impact statement. FONC believes this is

a serious legal error and that BLM's final decision will be compromised as a result. Nevertheless, FONC is hoping that the final version of the management plan addresses a significant number of the impacts and concerns raised by FONC in its comments and those of the many experts who reviewed the assessment. In particular, FONC strongly objects to the inclusion of a Marina Ranch Gate Parking Lot Compound in the final plan. For the plan to destroy one of the most sweeping views of the unique marine terrace habitat for parking would be a serious affront to the Proclamation and the integrity of the Monument. This result would be particularly egregious due to the presence of a much less impactful access location that is more convenient to the many local users who would be expected to use the Monument. As noted in our prior comments, FONC does not believe that the Environmental Assessment provides BLM with the necessary information to compare evaluate and ultimately select the alternative that best achieves the goals of the Presidential Proclamation. In order to ensure that BLM has the information it needs to select an alternative that best implements the Proclamation's goals, FONC has prepared the attached Addendum to the FONC Preferred Alternative submitted as Attachment 1 to FONC's comments dated April 1, 2020. FONC believes it cannot be disputed that Old Coast Road in the vicinity of Yellow Bank could be used to access a parking lot for the area which would not ruin what even BLM describes as the "sweeping marine terraces" which are "key scenic features" at Cotoni-Coast Dairies. The Addendum is attached hereto as Exhibit A.

In addition, Dr. Jacob Pollock has identified a critical compendium prepared by the California Department of Fish & Wildlife of eight new scientific studies that explore in detail impacts of recreational uses on wildlife and habitats in natural areas. The articles were recently published in the California Fish and Wildlife Journal for the Conservation and Management of California's Species and Ecosystems, Special Issue on "Effects of Non-consumptive Recreation on Wildlife in California" (<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178943&inline>) and are attached hereto as Exhibit B. As Dr. Pollock's brief review indicates, the new scientific papers "make clear is that these two management goals, recreational use and wildlife protection, are opposed to each other: more recreational use means less protection for wildlife. Additionally, the articles make it clear that managers must understand these incompatibilities and account for them in their planning and management." Jacob F. Pollock, Ph.D, Comment (July 24, 2020) (attached here to as Exhibit C).

When reviewing an action pursuant to the National Environmental Policy Act, 42 U.S.C. § 4332, *et seq.* ("NEPA"), the agency must take into account any responsible opposing scientific viewpoint, especially where such viewpoint has not been taken into account in the draft environmental review document, and "indicate the agency's response to the [scientific] issues raised." 40 C.F.R. § 1502.9(b). *See Ctr. for Biological Diversity v. U.S. Forest Serv.*, 349 F.3d 1157, 1167 (9th Cir. 2003). "This disclosure requirement obligates the agency to make available to the public high quality information, including accurate scientific analysis, expert agency comments and public scrutiny, before decisions are made and actions are taken." 40 C.F.R. § 1500.1(b). The use of an assessment should not be used as a means of avoiding the important role NEPA places on ensuring that BLM and other agencies meaningful confront the most recent

science available on sometimes difficult policy decisions. The new scientific articles identified by Dr. Pollock are significant new information which is extremely relevant to BLM's formulation of a management plan for the Cotoni Dairies portion of the Monument. Indeed, because the Presidential Proclamation only identifies the ecosystem and habitats, species dependent on those habitats, Native American cultural values, and marine coastal terraces overlooking the Pacific Ocean, as the objects intended to be protected, it is essential that BLM's effort to introduce recreational uses in the Monument take extra care that those uses not undermine the Monument's ecological, wildlife, cultural, and scenic values. *See* Presidential Proclamation 9563, pp. 3-4 (Jan. 12, 2017).

“Once an agency has prepared an EA and issued a FONSI, an agency must supplement its analysis if there are “significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.” *Oregon Nat. Res. Council Action v. U.S. Forest Serv.*, 445 F.Supp.2d 1211, 1219 (D. Or. 2006); 40 C.F.R. § 1502.9(c)(1)(ii); *Idaho Sporting Congress v. Thomas*, 137 F.3d 1146, 1152 (9th Cir.1998) (holding that an EA must be supplemented in the same manner as an EIS). “There is an obligation to supplement an EA if there remains major federal action to occur and the new information shows that the remaining action will affect the quality of the human environment in a significant manner or to a significant extent not already considered.” 445 F.Supp.2d at 1219, citing *Marsh v. Or. Natural Res. Council*, 490 U.S. 360, 374 (1989). The new studies published by Cal. Fish & Wildlife should convince BLM not to rely on an assessment and FONSI and instead prepare a full EIS for the management plan. At a minimum, BLM should recirculate the Assessment taking into account this new significant scientific information that has come to light.

Also significant to the BLM's anticipated action and the veracity of the Assessment is the Ninth Circuit's recent decision invalidating the U.S. Environmental Protection Agency's recent registration of the herbicide dicamba. *Nat'l Family farm Coalition, et al. v. U.S. Env't'l Protection Agency*, Case No. 19-70115 (slip op. June 3, 2020) (attached as Exhibit D). In addition to the obvious change that dicamba may no longer be available to BLM as a vegetation management tool, the Court of Appeals' decision also directly refutes the Assessment's assertion that “Dicamba is not a volatile compound, therefore it has no effects on air quality.” Assessment, Appendix F, p. 10. On the contrary, the record discussed by the Ninth Circuit states unequivocally

[Dicamba] has a well-known drawback. Dicamba is volatile, moving easily off a field onto which it has been sprayed. It can drift if the wind blows during application; it can drift if applied during temperature inversions; it can drift after application when it volatilizes, or turns to a vapor, during hot weather. As a result of its toxicity and its tendency to drift, dicamba had historically been used to clear fields, either before crops were planted or before newly planted crops emerged from the soil.

Opinion, p. 2. The Assessment is misleading on this point, stating the polar opposite. Again, the Ninth Circuit decision points to many reasons why an EIS should be prepared. At a minimum,

the Assessment should be amended and recirculated to address this significant new information relating to the proposed use of dicamba.

In addition to this significant new information, FONC would like note that one of the references to a paper in the California Fish and Wildlife Journal, Special Edition identified above is to the Interagency Visitor Use Management Council on which BLM is a collaborator. The Council's Website features a statement that:

Providing a consistent approach to visitor use management better serves the public by creating seamless connections between lands and waters managed by different federal agencies.

This recognition by BLM of the value of seamless connections between lands and waters managed for visitor use and other public purposes is not applied in the BLM RMPA/EA as to the adjoining San Vicente Redwoods (SVR). SVR has trails intended to connect to Cotoni-Coast Dairies and would be severely adversely impacted by BLM's proposed uses (e.g., hunting, camping, off-trail recreation, etc.) which are prohibited on SVR. Furthermore, SVR has adopted strong resource protective policies, procedures and standards which BLM does not even come close to matching. Rather than a seamless connection to SVR, BLM will be undermining SVR's management unless the RMPA ultimately proposed by BLM is revised to match what SVR has adopted.

Additionally, FONC is concerned that BLM is proceeding to apparently release a Proposed RMPA for public review in the continuing absence of issuance of any of the required consultation determinations or biological opinions by USF&WS or NOAA-NMFS regarding Cotoni-Coast Dairies.

Lastly, FONC joins in the concern recently raised by the Davenport North Coast Association. It was FONC's understanding, based on BLM's discussion with DNCA, that BLM was undertaking a traffic study for the RMPA. It also was our understanding that the traffic study would be shared with the public and an opportunity for review and comment be provided prior to BLM's final decision. The announcement today suggests that will not be the case. Absent a traffic study, the Assessment is significantly flawed. Any such study would be significant and should be released for review and comment along appropriate amendments made to the BLM's environmental document prior to the final decision.

For these reasons and those submitted in FONC's previous comments, the EA is deficient and fails to comply with BLM's duties under NEPA. Because there are numerous substantial questions that the various alternatives proposed by BLM may significantly degrade the Monument and almost all of the objects BLM is charged with protecting by Proclamation 9563, BLM must prepare and circulate an EIS in order to proceed with a management plan. FONC requests that all of its prior submittals (including submittals made individually by any expert or person whose communication is contained in an Exhibit to FONC's Comment Letter) be included in the record for BLM's proceedings involving an Environmental Assessment or

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Environmental Impact Statement related to the adoption of any Management Plan or amendment addressing Cotoni-Coast Dairies, or any Trail Construction or other Project thereon. Because of these concerns, FONC has endeavored to provide BLM with robust and accurate information which we hope may still result in a protective management plan for the Cotoni-Coast Dairies area. It is FONC's understanding that BLM has met with various groups interested in the Cotoni-Coast Dairies management plan decision. FONC would welcome an in person meeting (presumably outdoors and abiding by all current health rules and guidance resulting from the Covid-19 pandemic) to be scheduled at your earliest convenience, or at least a Zoom meeting, to discuss FONC's alternative and other concerns raised in its comments. In the meantime, thank you for considering these supplemental comments.

Sincerely,



Michael R. Lozeau  
Lozeau Drury LLP  
on behalf of Friends of the North Coast

Attachments

# EXHIBIT A



## **Addendum to FONC Preferred Alternative**

### **Overview**

The purpose of this Addendum is expand on the below quoted statements contained in FONC's Preferred Alternative which was Attachment 1 to FONC's Comment Letter submitted to BLM on April 1, 2020. **This Addendum will also demonstrate that the Access Site at Yellow Bank Creek, as proposed by FONC, can more quickly, efficiently, and legally be created and operational, including with the possibility of potable water and electrical service.**

“Phase 1: RMZ 3 – Create Parking and Access at Yellow Bank Creek in accordance with the following plan and photos in the following “Yellow Bank Alternative Access” Package.

Work with CalTrans and relevant other partners to establish:

- deceleration lane and left turn lane to access Yellow Bank Creek Parking Lot and Trailhead either at existing roadway to Yellow Bank Creek corral area or at Fambrini Farm Stand and then along Old Highway One to same corral area ...

\*\*

NO CONSTRUCTION AT OR ACCESS TO MARINA RANCH GATE BY ANY METHOD .... The Marina Ranch Gate Access Road, Parking Lot and Picnic Area ... will result in “objects” of the Monument such as ... scenic resources ... being subjected to excessive risk of harm.

\*\*

This image [of the incomparable sweeping marine coastal terraces] was taken off the BLM's Cotoni-Coast Dairies website. It shows the second marine terrace as seen from the third terrace. Ironically, it is a photo of the location of the "Marina Ranch Gate" parking lot as proposed in the BLM's Alternative C.

Here's the proposed parking lot with entrance road. The image came from the BLM's website. Because of the cattle, the road requires a fence around it at all points. There is also fence proposed around a picnic area (with benches and tables) and toilets. The bottom part of the road passes through a beautiful draw that is quite wet in the winter. This part of the road would require a lot of bulldozing to make it work.”

As will be discussed below, **clustered access and parking at the Yellow Bank canyon area complies with the Coastal Act, while the Marina Ranch Gate Parking Lot, Picnic Shelters, Restroom Building (collectively “Compound”), and long, inter-terrace Access Road do not.**



As will be further discussed, the Yellow Bank canyon area is already identified by BLM as a featured Access Site.<sup>1</sup> As can be seen from the Cover to this Addendum, there are a variety of methods to create access and parking for a Southgate in or adjacent to Yellow Bank canyon by use of a restored Old Coast Road. The quickest and least expensive initial method would be for a driver (whether travelling north or south) to head inland from current Highway 1 at the location of the existing informal entrance to the *ad hoc* Panther Beach Parking Lot and within about 50 feet be on the no-longer-used Old Coast Road. There is ample room here for a left turn lane and acceleration and deceleration lanes. Once on Old Coast Road a driver would travel north roughly parallel to current Highway 1 to a newly-constructed Parking Lot on BLM land on the south side of Yellow Bank canyon. From that 1<sup>st</sup> Terrace Parking Lot there is already access for pedestrians, bicyclists and equestrians (and apparently some vehicles):

south to the Cotoni Trail and the Yellow Bank South Loop; and

north down into the floor of Yellow Bank Creek canyon just inland of the corral area (from whence BLM's restored wetland ponds along Yellow Bank Creek can be visited) and back up to the 1<sup>st</sup> Terrace with its Yellow Bank North Loops and Bonny Doon Loops.

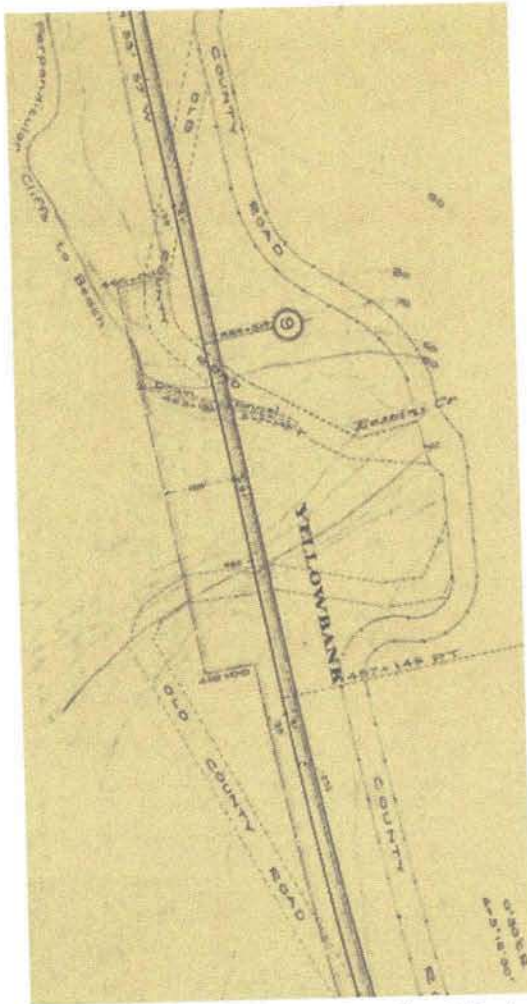
From the newly-constructed Parking Lot on the south side of Yellow Bank canyon Old Coast Road itself follows a cut across the south slope of the canyon-side down across Yellow Bank Creek and back up another cut across the north slope of the canyon-side to the 1<sup>st</sup> Terrace and then travels on north to where drivers can enter or exit Highway 1 at the Fambrini Farm Stand.

There are a myriad of possibilities at Yellow Bank. Notably, another newly-constructed Parking Lot could also be created on the north side of Yellow Bank canyon accessed at the Fambrini Farm Stand. And in light of the already existing graded roadway cuts, Old Coast Road could be restored to connect both sides of Yellow Bank canyon where additional Parking could be created or where exit from the canyon to Highway 1 could occur via the road currently used by the Grazing Operator. Additionally BLM has proposed a Bridge for pedestrians and bicyclists over Highway 1 from the area of the FONC-suggested south-side Parking Lot to the Rail-Trail's proposed redeveloped Panther Beach Parking Lot where BLM envisions shared parking could occur. There is also a tunnel under Highway 1 to Panther Beach which apparently the Coastal Commission would like to see explored. Another big advantage of the Yellow Bank location is proximity to City potable water and to electrical power. Opportunities abound.

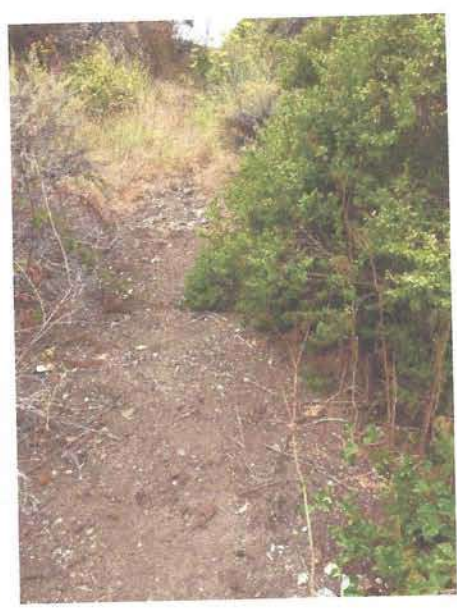
As can be seen from the 1912 map on the next page a (then) new county road (Old Coast Road) had been created to replace, in part, an older one. With one relatively minor exception, the bed of Old Coast Road is still intact, although largely overgrown. See photos on the next page.

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<sup>1</sup> BLM's Figure 5B identifies the Yellow Bank Creek canyon area as the sole "TH" ("Yellow Bank Trailhead") in Alternative B. Figure 5C identifies the Yellow Bank Creek canyon area as the sole "P" (Parking and Day Use Area) inland of Highway 1 south of Davenport.



Yellowbank Station according to an Ocean Shore Railroad survey map from 1912. (UC Santa Cruz)



**The Marina Ranch Gate Access Site is Inconsistent with the Coastal Act and Despoils the Key Scenic Feature of Cotoni-Coast Dairies.**

**A. The RMPA/EA Vastly Understates the Adverse Impacts to Scenic Quality if the Marina Ranch Gate Parking Lot Compound and Access Road are Included.**

BLM states that “[t]he broad view of the Pacific Ocean and *sweeping marine terraces are the key scenic features* of C-CD.” RMPA/EA p.37. Indeed these “marine coastal terraces overlooking the Pacific Ocean” are expressly mentioned in the Proclamation adding Cotoni-Coast Dairies to the California Coastal National Monument. FONC’s Vision Statement previously submitted to BLM includes the following:

“The undisturbed vista extending across Monterey Bay, to the Santa Lucia Mountains and the Ventana Wilderness, includes in its foreground a “snapshot in time,” a view astonishingly largely unchanged over the past 250 years..., a viewshed to remain permanently sacrosanct from any future development impact.”

BLM’s proposed Marina Ranch Gate Parking Lot Compound and Access Road are located in an area that BLM itself features photographically on its website. See next 3 pages for these photos and location from which they were taken. Yet ***BLM’s expressly stated objective is to reduce the level of protection of the scenic view*** of the sweeping marine terrace and the Pacific Ocean from Class II to Class III.<sup>2</sup> At Section 10.4.4 of the RMPA/EA, BLM itself takes the position that the Marina Ranch Gate area currently rates as a VRI Class II rating, meaning:

“Retain the character of the landscape: The level of change to the characteristic landscape should be ***low***. Management activities should be seen but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.”

However, BLM’s ***chosen*** objective for this site, with which it states the Marina Ranch Gate Parking Lot Compound and Access Road would be consistent, is VRI Class III, meaning:

“Partially retain the existing character of the landscape: The level of change to the characteristic landscape should be ***moderate***. Management activities may attract attention

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<sup>2</sup> FONC contends that the sweeping marine terrace in question qualifies as VRI Class I, meaning:

“Any new site developments on BLM lands will be located and designed so that they do not detract from coastal vistas. New facilities will be constructed so that the level of change to the characteristic landscape is very low and does not attract attention.”


Hence, the actual result is a reduction in protection from Class I to Class III. BLM has decided NOT to manage any portion of Coast Dairies as Class I. Management as Class I would require any new site development not to detract from Coastal Vistas.






# BLM View points

## Legend

 BLM photo looking

 BLM photo looking N

 BLM photo looking S

Google Earth

Data CSUMB SFML, CA.OPC

1000 ft



but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.”

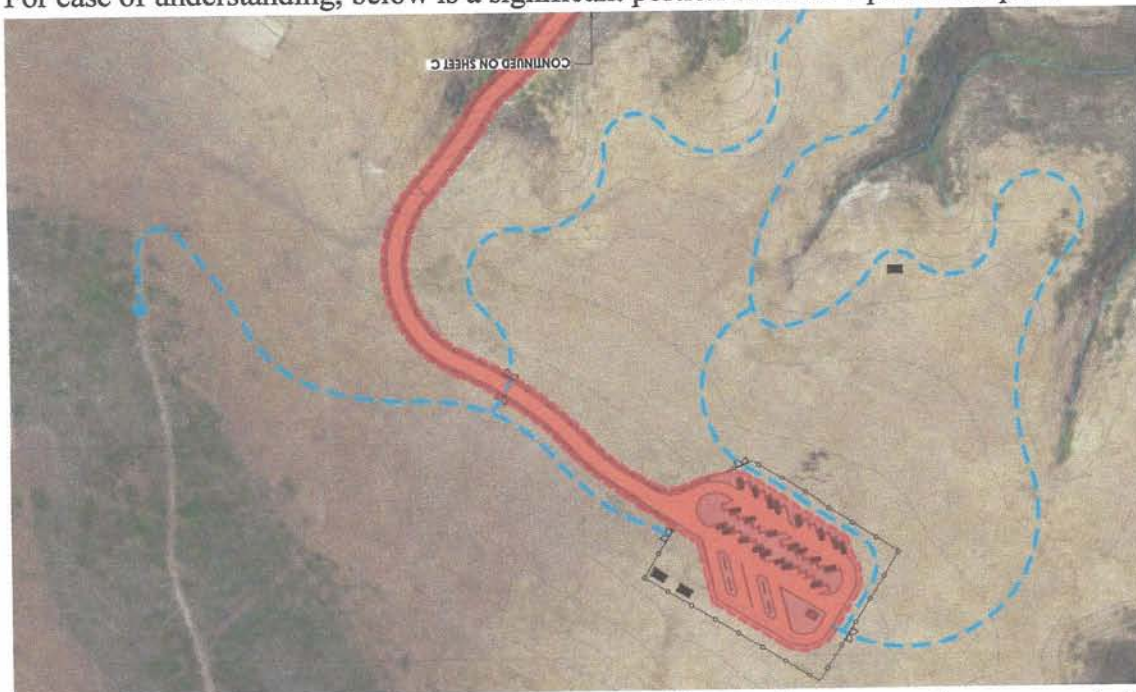
In its Visual Impacts Analysis BLM actually concludes that the Marina Ranch Gate Parking Lot Compound and Access Road “**would have a localized moderate to major adverse impact on scenic quality** ... consistent with the VRM Class III objective.” See, RMPA/EA p.47. FONC submits that BLM’s Alternative B Access Site Plan at Marina Ranch Gate will result in a major adverse impact on scenic quality and that it will be the opposite of “localized.” What follows is an illustrated demonstration of how the Marina Ranch Gate Parking Lot Compound and Access Road cause such a major and widespread adverse impact on the scenic quality at C-CD.

BLM’s design for its proposed construction of the Marina Ranch Gate Parking Lot Compound on the 2<sup>nd</sup> Terrace and an Access Road from Highway 1 to that Parking Lot can be found, in two parts, at the following web sites:

[https://eplanning.blm.gov/public\\_projects/lup/120855/20012873/250017666/RMPA\\_Appendix\\_B\\_Marina\\_Ranch\\_Gate\\_Parking\\_Concept\\_C.pdf](https://eplanning.blm.gov/public_projects/lup/120855/20012873/250017666/RMPA_Appendix_B_Marina_Ranch_Gate_Parking_Concept_C.pdf)

[https://eplanning.blm.gov/public\\_projects/lup/120855/20012874/250017667/RMPA\\_Appendix\\_B\\_Marina\\_Ranch\\_Gate\\_Parking\\_Concept\\_D.pdf](https://eplanning.blm.gov/public_projects/lup/120855/20012874/250017667/RMPA_Appendix_B_Marina_Ranch_Gate_Parking_Concept_D.pdf)

For ease of understanding, below is a significant portion of BLM’s published plan.



The adverse impact on scenic quality to these sweeping marine terraces is compounded by the long, fenced, inter-terrace Access (Entry) Road through the beautiful draw (a potential wetland) and the 2<sup>nd</sup> Terrace meadow to the Parking Lot near the top of the 2<sup>nd</sup> Terrace, together with requiring alteration of natural land forms by grading a total of 4.57 acres. The Parking Lot for 42 vehicles and 4 equestrian trailers is 1.82 fenced acres and will include two of the three Picnic

Shelters (with benches and tables), as well as a Restroom Building. The third Picnic Shelter will also be visible on the 2<sup>nd</sup> Terrace.

The entire area shaded in light blue on the Topographic Map below will have a view of the Parking Lot Compound and/or the Access Road to it. Thus, the Marina Ranch Gate Compound and Access Road is located right in an area where it is visible from vast portions of the 2<sup>nd</sup> and 3<sup>rd</sup> Terraces.



Photos are included below from each of the numbered locations on this Topographic Map. The proposed Marina Gate Parking Lot Compound and its Access Road are indicated on the Topography Map above in purple.

What will make this Parking Lot Compound and Access Road particularly visible is its location. Being on the 2<sup>nd</sup> Terrace, it will be visible from the 3<sup>rd</sup> Terrace at its side facing the ocean, and from the entire 2<sup>nd</sup> Terrace, which is flat and visually unobstructed.



- 1) Points 1, 2, 3, and 4 are somewhat distant from the Parking Lot Compound, but nonetheless it would be in their view.



2)



3)



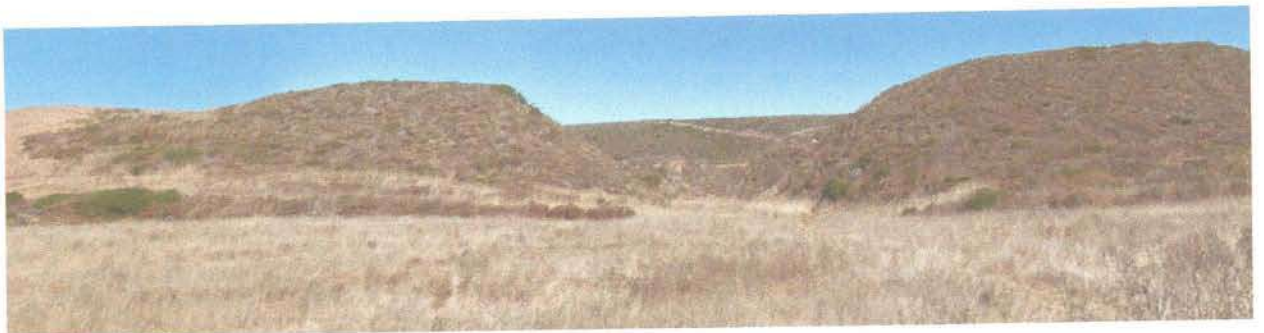
4) The view from the 2nd Terrace about a half a mile further north. The detail enlarged is a corral that is currently next to the proposed Parking Lot Compound site.



5) The view from the 3<sup>rd</sup> Terrace directly inland from the proposed Parking Lot Compound, with the approximate location of the Parking Lot Compound and Access Road.



6) The view from Highway 1 into the draw where the Access Road would be constructed.



**The RMPA/EA vastly understates the adverse impacts to scenic quality when it describes them as moderate and localized. Indeed, the Marina Ranch Gate Plan will despoil the “sweeping marine terraces” the “key scenic feature” of the Southgate area of Cotoni-Coast Dairies.**

**B. The Marina Ranch Gate Plan is Inconsistent with the California Coastal Act**

Under Public Resources Code Section 30116 the term “Sensitive coastal resource areas” warranting protection under the Coastal Act is defined as follows:

“those identifiable and geographically bounded land and water areas within the coastal zone of vital interest and sensitivity. “Sensitive coastal resource areas” include the following:

- (a) Special marine and land habitat areas, wetlands, ...
- (b) Areas possessing significant recreational value.
- (c) Highly scenic areas.

Thus, the Coastal Act protects the view from the trails planned at Cotoni-Coast Dairies overlooking this key sweeping marine terrace proposed to be despoiled by the Marina Ranch Gate fenced Parking Lot/Picnic Shelters/Restroom Building Compound. The Coastal Act also protects the natural landforms, environmentally sensitive habitat area, and wetlands in the beautiful draw that the fenced Access (Entry) Road would traverse.

Public Resources Code Section 30251 (a part of the Coastal Act) provides as follows:

The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. *Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms*, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas.....

Public Resources Code Section 30240(a) provides that environmentally sensitive habitat areas [ESHA] shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.

Public Resources Code Section 20333 provides that (a) The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to the following:

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(4) Incidental public service purposes, including, but not limited to, burying cables and pipes or inspection of piers and maintenance of existing intake and outfall lines.

\*\*

(6) Restoration purposes.

(7) Nature study, aquaculture, or similar resource-dependent activities.

Under Coastal Commission policy, “incidental services” may include, under certain circumstances, road expansion: “When no other alternative exists, and when consistent with the other provisions of this section, limited expansion of roadbeds and bridges necessary to maintain existing traffic capacity may be permitted.” *Bolsa Chica Land Trust v. Superior Court* (1999) 71 Cal.App.4th 493, 515–16, 83 Cal. Rptr. 2d 850, 863 (1999), disapproved of on other grounds by *Dhillon v. John Muir Health*, 2 Cal.5th 1109, 394 P.3d 1048 (2017).

The Coastal Commission addressed some of the issues related to the Marina Ranch Gate Parking Lot Compound and Access Road in its April 3, 2020 Comment Letter to BLM regarding BLM’s RMPA/EA, stating as follows.

The Coastal Act requires appropriate protections for coastal resources, a term that is understood broadly to apply to public recreational access, but also to ESHA, **public views**, agriculture, and virtually all of the other resources in play in the proposed RMPA.

\*\*

Similarly, in terms of other important coastal resource considerations for the RMPA, the Coastal Act also requires ... that development be sited and designed to protect public views to and along the ocean and scenic coastal areas (Section 30251). These Coastal Act requirements define what can and cannot be allowed under the RMPA for the Cotoni-Coast Dairies property, including as it applies to ... ***its sweeping and incomparable vistas***. Emphasis added.

.... [B]ecause Alternative A proposes minimal development, adverse impacts to visual resources have been correspondingly minimized. That being said, **one of the primary benefits of public access trails at Cotoni-Coast Dairies is the dramatic ocean views that the trails would provide for the public**. Alternative A’s lack of trails means that this benefit would not be realized, and **Coastal Act Section 30251’s intent to maximize ocean and coastal view opportunities** would not be fulfilled.

In terms of public views, both Alternatives B and C would appear to minimize impacts to visual resources, including via siting the parking lots out of the public viewshed to the extent feasible. These two alternatives also, as described earlier, ***open up a vast panorama of public views from the new trails*** and associated facilities, which would significantly enhance public viewshed opportunities. ***Any development (e.g., parking***

*lots*, visitor/informational center, kiosks, etc.) **would require careful siting** and design to both minimize the potential for adverse view impacts, and also to ensure that such facilities blend into the natural environment to the extent feasible (e.g., through the use of natural materials, appropriate screening with native plants, low-key signage, etc.).

In support of its statement above that the RMPA/EA “would appear to minimize impacts to visual resources, including via siting the parking lots out of the public viewshed to the extent feasible” Footnote 12 in the Coastal Commission Comment Letter states in relevant part as follows: “<sup>12</sup> For example, ... siting the Marina Ranch Gate parking area inland and uphill from Highway 1 in Alternatives B and C; ....” This seems to imply that only views from Highway 1 are protected. However, elsewhere in the Comment Letter the Coastal Commission staff make it clear that views from trails are also to be protected. As BLM has expressly stated, “[t]he broad view of the Pacific Ocean and **sweeping marine terraces are the key scenic features of C-CD.**” Emphasis added. *See also*:

- (1) May 3, 2004 Memo to Commissioners and Interested Persons from Peter Douglas, Executive Director stating that: “[t]he Coastal Commission has implemented scenic resource protection policies primarily by focusing on land-based scenic views from public parks, trails, roads and vista points.”
- (2) CDP Appeal Staff Report dated February 14, 2003 in A-2-MAR-02-024 (Hansen/Brubaker) recommending a Commission Finding of Substantial Issue regarding protection of visual resources (albeit under a County LCP rather than the Coastal Act itself – but the reasoning is analogous). At issue was development surrounding an approximately 4,600-square-foot central courtyard, effectively creating a nearly 10,000- square foot compound<sup>3</sup> in the landscape east of Tomales Bay which consists of relatively pristine open grassy hillsides with some forested drainage ravines. **The hillsides create a scenic panorama, which is visible from many public-viewing locations including State and National Parks** and State Highway 1. As proposed, the development would be located approximately two-thirds of a mile away from State Highway 1 on the upper portion of the property. An existing stand of California bay laurel trees downslope of the building site would serve as partial screening for the proposed development; however, portions of the residential development would still be visible from public locations such as Point Reyes National Seashore and the waters of Tomales Bay. **In addition, the improvement of the historic farm road will make the road more visible.** Thus, the approved design of the project raises a substantial issue with respect to whether it has minimized visual impacts. Similarly, inasmuch as the project’s visual impacts could be further minimized, it is not compatible with the natural environment of the Tomales Bay landscape. For example, the development could be sited at the lower portion of the property adjacent to Highway 1. **Clustering the development near the highway would substantially reduce the length of the access road and would**

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<sup>3</sup> The Marina Ranch Gate Parking Lot alone is roughly 8 times this size.

*minimize the visual impacts of the development as viewed from Point Reyes and other public viewing areas.*

Thus it is clear that the Coastal Commission has a track record of evaluating the impacts on visual resources from public viewing areas other than scenic highways, including public parks, trails, and vista points. Furthermore, impacts from improvement of historic farm roads must be considered.

As in the Marin County (Tomales Bay) situation, clustering development near Highway 1 at Yellow Bank Creek would have less impact on the "key scenic features of Cotoni-Coast Dairies," specifically identified as the "broad view of the Pacific Ocean and sweeping marine terraces." This is particularly true given that the Coastal Commission Comment Letter appears open to exploring BLM's proposed Pedestrian/Bicycle Bridge at the Panther Beach Rail-Trail Parking Lot crossing Highway 1 adjacent to Yellow Bank canyon (and even a possible underpass given that a tunnel already exists under Highway 1 to Panther Beach from Yellow Bank Creek). As proposed by BLM, the Pedestrian/Bicycle Bridge terminates at one of FONC's proposed Parking Lots (on the 1<sup>st</sup> Terrace above Yellow Bank canyon on its south side. This Parking Lot would be largely (if not entirely) obscured from Highway 1 by existing vegetation and served by Old Coast Road parallel to current Highway 1.

The Santa Cruz County LCP is also relevant to any analysis of the visual impacts of development of an access site at Marina Ranch Gate. That is because (as previously explained to BLM) the Grant Deed from CDLC to BLM (attached) states on pages 1-2 that:

"THE SUBJECT PROPERTY IS CONVEYED SUBJECT TO THE FOLLOWING PROVISIONS:

.....

The parties intend that the ultimate use of the subject property is set forth in more detail in, and guided by, that certain Management Plan titled 'Coast Dairies Long Term Resource Protection and Access Plan' dated February 2004, and as such plan may be modified or updated pursuant to the public planning process thereafter."

The LTRP&A Plan then states at page I-7 under "Agency Reviews and Approvals" that:

"Table I-1 identifies agency anticipated review and approvals required for full implementation of the Coast Dairies Plan. Additional detail is provided in Appendix A.

Table I-1 AGENCY REVIEW AND APPROVALS FOR THE COAST DAIRIES PLAN

Agency	Required Approval
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.....

.....

.....

.....

.....  
County of Santa Cruz

.....  
Coastal development permits

Appendix A, at pages A-2 through A-4 makes it even more clear that including the Marina Ranch Gate Access Site and Parking Compound requires a Coastal Development Permit from the County of Santa Cruz, stating at page A-4 that:

"Coastal Development Permits. Developments within the Coastal Zone must obtain a coastal development permit in addition to any other approvals or permits required. Implementation of the Coast Dairies Plan will not result in any actions that require a coastal development permit. ***Future applicable implementation actions tiered from the Coast Dairies Plan will be required to obtain coastal development permits.***"

The Coast Dairies Plan does not include the proposed Marina Ranch Gate Parking Lot Compound and Access Road, hence it is a "future implementation action" and "required to obtain [a] coastal development permit."

Furthermore, in interpreting the Coastal Act where a LCP has been certified, the Coastal Commission gives consideration to the contents of that LCP. The County of Santa Cruz LCP contains the following provisions which support FONC's position that the Marina Ranch Gate Parking Lot Compound and Access Road is inconsistent with the intent of the Coastal Act as to protection of visual resources and prevent impacts from public vistas.

#### **5.10.2 Development Within Visual Resource Areas**

(LCP) Recognize that visual resources of Santa Cruz County possess diverse characteristics and that the resources worthy of protection may include, but are not limited to, ocean views, agricultural fields, wooded forests, open meadows, and mountain hillside views. Require projects to be evaluated against the context of their unique environment and regulate structure height, setbacks and design to protect these resources consistent with the objectives and policies of this section. Require discretionary review for all development within the visual resource area of Highway One, outside of the Urban/Rural boundary, as designated on the GP/LCP Visual Resources Map and apply the design criteria of Section 13.20.130 of the County's zoning ordinance to such development.

#### **5.10.3 Protection of Public Vistas**

(LCP) ***Protect significant public vistas*** as described in policy 5.10.2 ***from all*** publicly used roads and ***vista points*** by ***minimizing disruption of landform and aesthetic character caused by grading operations***, timber harvests, utility wires and poles, signs, inappropriate landscaping and structure design. Provide necessary landscaping to screen development which is unavoidably sited within these vistas. (See policy 5.10.11.)

As demonstrated above, the Marina Ranch Gate Compound (including its Access Road) will utterly ruin what the Coastal Commission Comment Letter recognized as Cotoni-Coast Dairies “sweeping and incomparable vistas,” “a vast panorama of public view from the new trails.” This is inconsistent with the Coastal Act. It doesn’t have to be that way. As explained below **there is a vastly superior alternative** by clustering parking and access at Yellow Bank Creek canyon by repurposing the currently unused Old Coast Road.

## II

### **Clustering Development Near Highway 1 at Yellow Bank Creek Would Have Negligible Impact on the “Key Scenic Features of Cotoni-Coast Dairies,” Specifically Identified as the “Broad View of the Pacific Ocean and Sweeping Marine Terraces.”**

Clustering development near Highway 1 at and above Yellow Bank canyon is already part of BLM’s RMPA; FONC simply proposes a more effective clustering which will more quickly and less expensively produce BOTH an initial access and parking area and the greatest long term opportunities. Already BLM’s Figure 5B identifies the Yellow Bank Creek canyon area as the sole “TH” (“Yellow Bank Trailhead”) in Alternative B. Figure 5C identifies the Yellow Bank Creek canyon area as the sole “P” (Parking and Day Use Area) inland of Highway 1 south of Davenport. Also at Yellow Bank BLM proposes shared use of the Rail-Trail’s redeveloped Panther Beach Parking Lot and BLM’s Pedestrian/Bicycle Bridge over current Highway 1 to a point where Old Coast Road reaches the southern side of Yellow Bank canyon<sup>4</sup>. Old Coast Road then descends into the base of the canyon, crosses Yellow Bank Creek, and ascends the north side of the canyon on its way to the Fambrini Farm Stand. Taking advantage of this existing overgrown historic roadbed, the grading for which has already occurred, is far less environmentally damaging, allows for clustering impacts on visual resources while offering myriad alternatives for access and location of parking. **Perhaps most compelling is that access and adequate parking can more quickly, efficiently, and legally be created and operational, including with the possibility of potable City water and electrical service.**

Taking the approach of providing initial parking near the south side (or both sides) of Yellow Bank canyon accessed<sup>5</sup> off Highway 1 from south or north via Old Coast Road opposite the entry to the Panther Beach Parking Lot would have less impact on the “key scenic features of Cotoni-Coast Dairies,” specifically identified as the “broad view of the Pacific Ocean and sweeping marine terraces.” Nor would this parking be nearly as visible (if at all) from current Highway 1

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<sup>4</sup> The Coastal Commission Comment Letter states as follows:

In terms of a potential Highway 1 crossing, we believe that it is possible that a pedestrian bridge can be constructed in a way that is sensitive to public views, and we would support exploring a pedestrian bridge as well as under-highway crossings (e.g., similar to what exists at Wilder Ranch) to facilitate public recreational access connectivity to the rail trail and Panther Beach.

Indeed a tunnel already exists under Highway 1 to Panther Beach from Yellow Bank Creek. See last page.

<sup>5</sup> Access includes entry and exit. Furthermore, if the Old Coast Road roadbed already cut down to the Yellow Bank Corral were restored, additional parking is available there and an additional exit could be available via the existing road off Highway 1 down to the corral area.



as the existing or redeveloped Panther Beach Parking<sup>6</sup> because it would be largely (if not entirely) obscured from Highway 1 by existing vegetation and served by Old Coast Road parallel to current Highway 1. There would ample opportunity for deceleration and acceleration lanes entering and exiting Old Coast Road. Furthermore, the entry/exit from current Highway 1 could be directly across from the entry/exit for the joint Rail-Trail/BLM Panther Beach Parking Lot on the coastal side of current Highway 1. There is adequate room for left turns from lanes similar to the design at Bonny Doon Road/Bonny Doon Beach Parking Lot. Adequate sight lines exist at this location. See Photos on following pages and Addendum Cover.

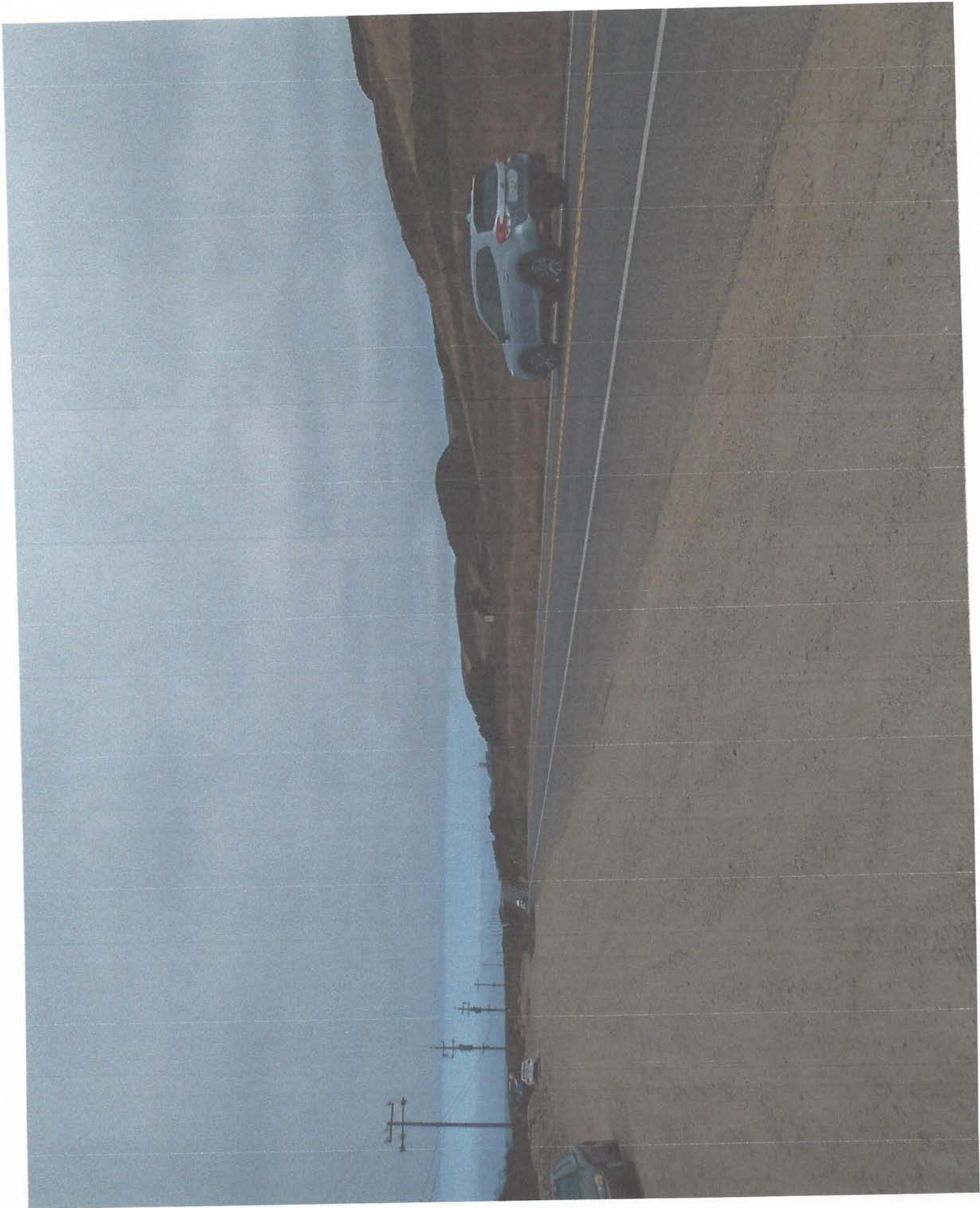
Another FONC-supported clustered Parking Lot not visible from current Highway 1 could be created at the same time or later near the north side of Yellow Bank canyon and accessed via Old Coast Road at Fambrini Farm Stand with adequate sight lines and ample opportunity for deceleration and acceleration lanes. See Addendum Cover.

As funds materialize in the future these two access and parking points could be connected by restoration of Old Coast Road for pedestrian, bicycle, equestrian, and even vehicular use. If desirable, parking is also available on the canyon floor at Yellow Bank now via the existing road off current Highway 1 or in the future off restored Old Coast Road. See Addendum Cover for a visual representation of this route and potential parking areas on the canyon floor.

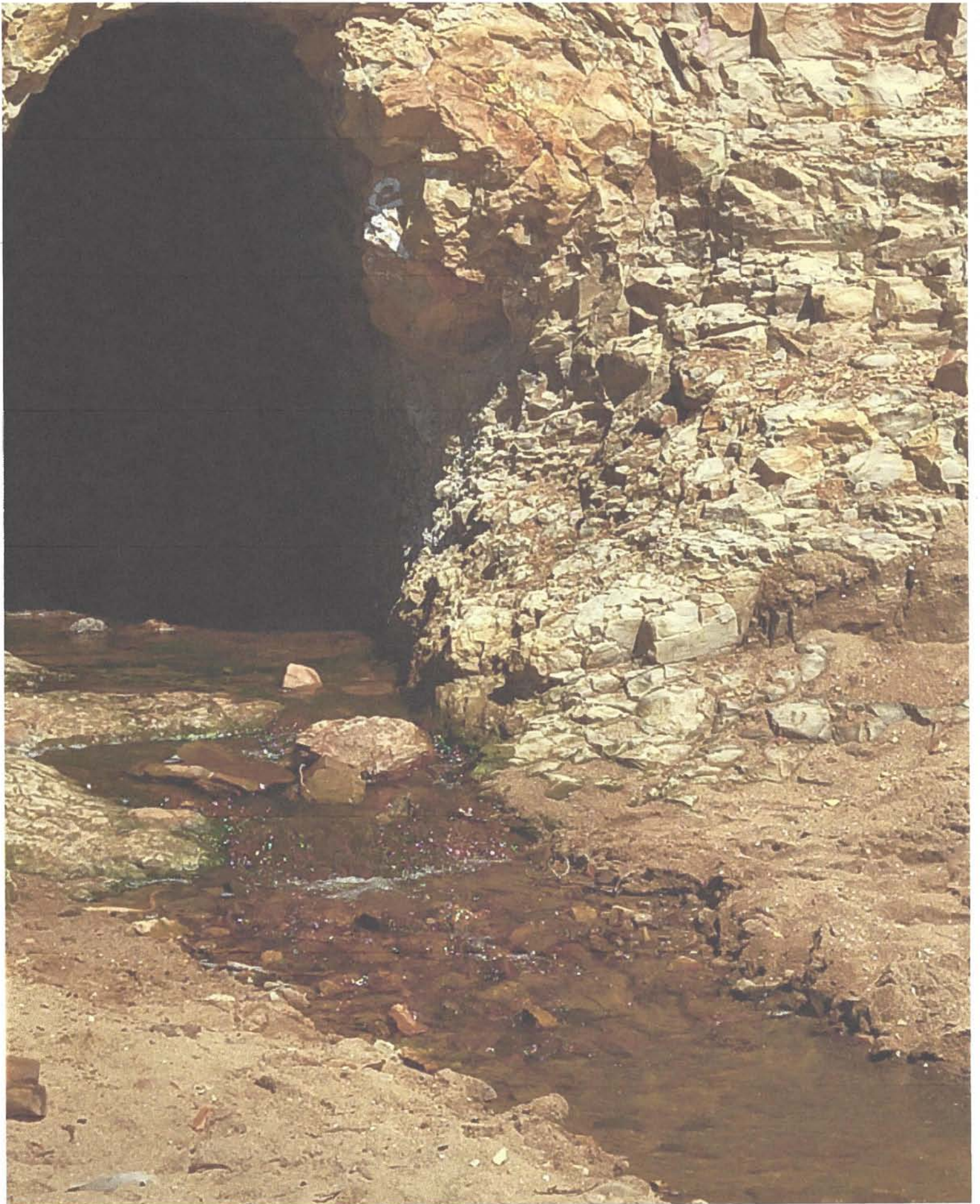
This clustered access and parking at Yellow Bank would at minimum preserve the Class I or II Visual Resources represented by the sweeping marine coastal terraces shown on the BLM website (as well as following page 4) and identified by BLM as the key visual resources at Cotoni-Coast Dairies, and would, most critically, enable compliance with the California Coastal Act. At the same time this approach would allow for the quickest, most efficient, most legally compliant, and least expensive access to Cotoni-Coast Dairies.

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<sup>6</sup>Not to mention, if approved by the Coastal Commission, the more dominating visual impact of a Pedestrian/Bicycle Bridge shown by BLM as terminating in the area where FONC's proposed initial Parking Lot is suggested on the 1st Terrace above Yellow Bank canyon on its south side.







# EXHIBIT B

# California Fish and Wildlife **JOURNAL**

**SPECIAL ISSUE**

Effects of Non-consumptive Recreation on Wildlife in California



*Journal for the Conservation and Management of  
California's Species and Ecosystems*

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# California Fish and Wildlife

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RECREATION SPECIAL ISSUE 2020

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Ange Darnell Baker  
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## Introduction

### CAN OUR OUTDOOR ENTHUSIASM AND NATURE COEXIST?

RON UNGER, *Environmental Program Manager, Landscape Conservation Planning Program, Habitat Conservation Planning Branch, California Department of Fish and Wildlife*

[Note: As this special edition journal is published, our State, the nation, and the whole world are gripped by the corona virus pandemic. To slow its spread and not overwhelm limited healthcare resources, voluntary and mandatory directives for staying home, social distancing, and closing parks, reserves, and other public facilities have been put in place on a scale not seen for a hundred years, the time of the 1918 influenza (flu) epidemic.

Stories are emerging of more secretive wildlife seen in some park and urban areas normally filled with people, like the reports of bobcats roaming around empty Yosemite facilities, or an adult black bear roaming the nearly empty downtown Solvang. Hopefully, the pandemic and its horrible devastation will be over very soon, and we may again visit and appreciate our parks and wilderness areas. Hopefully, too, we may gain more information on wildlife's response to fewer visitors that helps us improve our management of parks and reserves in a way that protects wildlife and their habitat while also providing for great recreation experiences.]

“Everybody needs beauty as well as bread, places to play in and pray in, where nature may heal and give strength to body and soul alike” (The Yosemite, 1912). John Muir wrote so eloquently of the importance of taking time to be in, and play in, Nature to heal and nourish our spirit and help us to balance the challenges of our everyday lives. Now more than ever, people find a need to balance their work and domestic lives with the wonders, serenity, and invigorating challenges inherent in playing in Nature. In a world increasingly dominated by computers, cyberspace, and cities, people find a need to go and enjoy the Great Outdoors.

But what is the capacity of Nature to absorb the onslaught of millions of us hiking, riding, flying, boating, and otherwise tromping around the forests, fields, mountains, valleys, streams, and rivers on the other 40,000 or more species that also live in and depend on California? An increasing body of evidence is emerging that indicates non-consumptive recreational activities like hiking and biking, which don't involve harvesting of resources, can have harmful effects on species, their habitat, and efforts to protect them. As our population continues to grow and new and popular recreation technologies develop, California's natural areas are experiencing increased and changing recreation demands, such as increased numbers of hikers, nighttime group trail biking with lights, and electronic mountain bikes in wilderness areas.

Many federal, state, and local agencies' missions include non-consumptive, outdoor recreation, since it is often believed to be consistent with wildlife conservation. It is also widely believed that those who know and observe Nature are more likely to appreciate and protect her resources. Recently, however, several sites acquired primarily for conservation

have experienced extreme recreation pressures such as the Disney-like crowds coming out to see “superblooms” of native flowers of the desert in the spring or mountain biking occurring in areas where it is illegal along with the creation of several miles of unauthorized trails. So, how can we continue to provide for and manage appropriate, legal recreation opportunities while also protecting California’s amazing and vast diversity of plants, fish, and other wildlife species and their habitats? How and where can we acquire separate lands for recreation access and for protecting habitat instead of frequently demanding too much recreation access on lands set aside for conservation of species and habitat? And, how can we facilitate various consumptive and non-consumptive recreation groups (e.g., hikers, mountain bikers, equestrians, off-highway vehicle users, hunters, anglers) and conservation groups (e.g., environmental activists, land trusts, resource agencies) to work together to advocate for acquiring and managing separate recreation and conservation lands instead of increasingly coming into conflict with one another over the use of the same lands for both purposes?

This special edition journal seeks to tackle this and related questions. In the introductory essay, “Non-consumptive Recreation & Wildlife Conservation: Coexistence through Collaboration,” Dr. Ashley D’Antonio points out the unique need and opportunity California has for addressing recreation use as a social-ecological system (SES) based on its high biodiversity and quickly increasing recreation use of protected lands. Mitrovich, Larson, Barrows, Beck, and Unger, in “Balancing Conservation and Recreation,” point to a need for recreation and conservation stakeholders to work together to ensure that sufficient areas are acquired for both uses and to help plan and manage conservation lands better to reduce adverse effects on wildlife and natural resources. They summarize some of the varied research going on in the field, on wildlife behavior and physiology, habitat degradation and fragmentation, reproduction and survival, community composition and richness, and other topics. Indirect effects like the shifts in day and night activity patterns between predators and prey lead to questions on what effects that has on wildlife interactions and possible changes that may lead to in a whole ecosystem. Two case studies cover visitor perceptions and values, and the importance of having groups with different values come together and work through their differences to build trust and facilitate better management decisions and stakeholder support.

The research paper, “Increased hiking and mountain biking are associated with declines in urban mammal activity,” by Larson, Reed, and Crooks provides findings on how some wildlife can respond rapidly to changes in the levels of human disturbance, which may help planners design targeted trail closures to reduce recreation impacts in important areas. Townsend, Hammerich, and Halbur conducted somewhat similar research to that of Larson, Reed, and Crooks and present their findings in “Wildlife occupancy and trail use before and after a park opens to the public.” Their research provides good insights into how differently various wildlife species respond to trail use by people, including strong differences in how soon and how much species may habituate to people’s presence. Baas, Dupler, Smith, and Carnes make the case in “An assessment of non-consumptive recreation effects on wildlife: current and future research, management implications, and next steps” for doing more research to help wildlife and park managers more effectively manage and respond to non-consumptive recreation impacts on wildlife species and their habitats.

Elizabeth Lucas points out deficiencies and a need to improve how recreation is sited, monitored, managed, and enforced in protected areas in her paper, “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.” She also provides a review

of several research papers in her paper, “A review of trail-related fragmentation, unauthorized trails, and other aspects of recreation ecology in protected areas.” Elizabeth points out the need for sufficient funding, science-based approaches to managing protected areas, and educating the public on recreation effects on wildlife, to achieve real protection of species and to retain the benefits of the protected lands. Elizabeth suggests several funding options including a compelling argument for establishing a recreation equipment excise fee or tax like those paid for over 80 years now by hunters and anglers to benefit habitat conservation. With so much use of outdoor areas now by “non-consumptive” recreation uses, and with declining popularity of hunting activities in the population at large, is it time to institute such a change for recreational users to pay their share of conserving and managing habitat?

Together, the articles in this special journal edition cover a broad array of research on recreation effects on wildlife. They provide interesting perspectives and offer a variety of solutions. Learning how to best manage non-consumptive recreation to provide great outdoor experiences while minimizing harmful effects on wildlife will continue to evolve as we learn more from research and experience. We hope that you find this special edition journal useful in your own exploration of this important and emerging field.

“Keep close to Nature’s heart... and break clear away, once in a while, and climb a mountain or spend a week in the woods. Wash your spirit clean.” –*John Muir*

## Introduction--continued

### NON-CONSUMPTIVE RECREATION AND WILDLIFE CONSERVATION: COEXISTENCE THROUGH COLLABORATION

ASHLEY D'ANTONIO, PHD, *Assistant Professor in Nature-Based Recreation Management, Gene D. Knudson Forestry Chair, Department of Forest Ecosystems and Society, Oregon State University*

The most basic principle in the field of recreation ecology—an interdisciplinary field that studies the ecological impacts of recreational activities and the management of these impacts—is that if outdoor recreation is allowed in an area, impacts to that ecosystem are inevitable. It is also established that outdoor recreation has a myriad of benefits to society that range from economic growth, improved human health and well-being, community building, and increases in an individual's connection to nature. Moreover, outdoor recreation is one of the primary mechanisms by which humans interact with the natural world in contemporary society. As a result, many county, state, and federal park and protected area (PPA) managers around the United States (U.S.) are faced with mandates or missions that require conserving natural resources while also providing quality outdoor recreation experiences. Key challenges facing researchers, conservation practitioners, and PPA managers as they try to balance conservation goals with recreation access are: understanding the mechanism and the level and extent of these impacts; identifying what level of negative impact, if any, is acceptable; and deciding how to mitigate or manage these impacts.

Within recreation ecology, the impacts from recreation to ecosystem components such as soil and vegetation are relatively well studied. The negative impacts of recreation to environmental factors such as water, air quality, soundscapes, and wildlife are less well understood. Studying the relationships between non-consumptive recreation use and impacts to wildlife can be complex. Part of this complexity is because impacts to wildlife can be direct (e.g., harassment or feeding) and/or indirect (i.e., habitat modification) and at times can be hard to measure or observe (e.g., changes in stress hormone levels in response to recreation presence) as compared to soil or vegetation impacts. Additionally, impacts from non-consumptive recreation use can be interacting with, or compounded by, other ecosystem pressures. These added pressures include, but are not limited to, habitat loss due to development or changes in land use, pressures from consumptive recreation (hunting or fishing), and/or climate change. Moreover, impacts at the wildlife population or community level often require long-term studies, which are somewhat rare in recreation ecology but admittedly more common in the wildlife sciences.

Despite these challenges, there is a recent resurgence of interest in studying the impacts of non-consumptive recreation use on wildlife species. Meanwhile, there is a recognition that studies focusing only on the social or human aspects of a PPA system are insufficient to address current recreation and conservation issues, especially those related to wildlife. Many recreation ecologists, conservation scientists, and managers have begun to view outdoor recreation in PPAs as a complex social-ecological system (SES). As such, we must enhance our understanding of the interactions and intersections between both the ecological and social systems that make up our PPAs. Addressing wildlife conservation and recreation

access in PPAs requires SES-focused thinking and collaborative problem solving.

The rich social and ecological systems comprising California make this state an excellent place to begin to address recreation use through an SES framework. California is one of the most biodiverse states in the U.S. and while 47% of the state is currently protected, 97% of these protected lands are opened to human access. Non-consumptive recreation use in PPA has increased rapidly in recent years across the U.S. but especially in Western states. California State Parks saw a 10% increase in total visitation numbers from the 2015/16 to 2016/17 fiscal year and many California national parks have seen exponential growth in visitation in recent years. As the U.S population becomes increasingly suburban and urban, PPAs that provide refugia and critical habitat for wildlife face increasing pressure from land use change and suburban expansion. Within California, this trend is evident as the state's population continues to grow while land use change, extreme droughts, and development increases pressure on California's PPAs.

Currently, PPAs and open space are limited, and wildlife species and their habitat face many ecological pressures. We are on the cusp of a resurgence and upswell of research exploring non-consumptive recreation impacts on wildlife. However, to meet conservation objectives, additional research is still needed to best inform recreation management in PPAs. Conserving and protecting wildlife species while providing quality recreation experiences to society requires interdisciplinary and transdisciplinary teams of researchers, managers, practitioners, stakeholders, and the public working together towards shared goals and objectives. Because of the social and ecological complexities and uncertainties around recreation impacts to wildlife, no individual field of science or management entity will be able to address this issue on its own. As such, this special issue is timely and important as it adds to the body of literature aimed at understanding non-consumptive recreation impacts to wildlife. Additionally, this special issue serves as a starting point for cooperatively exploring the challenge of protecting wildlife while balancing non-consumptive recreation use. If we are to meet conservation goals related to wildlife and wildlife habitat, it may not be appropriate to allow recreation use in all PPAs and at all times. However, collaborative dialogues (informed by the SES framework) around wildlife conservation are essential to guide decisions related to where, when, and how non-consumptive recreation use should be permitted in our PPAs.

## **Balancing conservation and recreation**

MILAN MITROVICH<sup>1\*</sup>, COURTNEY L. LARSON<sup>2</sup>, KATIE BARROWS<sup>3</sup>, MICHAEL BECK<sup>4</sup>, AND RON UNGER<sup>5</sup>

<sup>1</sup>*Natural Communities Coalition, 13042 Old Myford Road, Irvine, CA 92602 USA; ICF, 49 Discovery, Suite 250, Irvine, CA, USA*

<sup>2</sup>*Department of Fish, Wildlife & Conservation Biology, 901 Amy Van Dyken Way, #999, Colorado State University, Fort Collins, CO 80523, USA; The Nature Conservancy, 258 Main Street, Suite 200, Lander, WY 82520, USA*

<sup>3</sup>*Coachella Valley Conservation Commission, 73710 Fred Waring Drive, Suite 200, Palm Desert, CA 92260 USA*

<sup>4</sup>*Endangered Habitats League, 8424 Santa Monica Boulevard, Suite A 592, Los Angeles, CA 90069, USA*

<sup>5</sup>*California Department of Fish and Wildlife, Habitat Conservation Planning Branch, P.O. Box 944209, Sacramento, CA 94244-2090, USA*

*\*Corresponding Author: milan.mitrovich@icf.com*

Key words: California, equestrian, Habitat Conservation Plans, hiking, horseback riding, human dimensions, Natural Community Conservation Plans, mountain biking, trails, wildlife

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As California's population has grown to nearly 40 million people, and as the State's beautiful natural diversity draws tourists and explorers from around the world, outdoor recreation has also grown (California Department of Parks and Recreation 2013, 2017; Monz et al. 2019). New equipment and technology enable new activities, such as night-time mountain biking, while social media brings increasing numbers of people to areas seldom visited by people only ten or twenty years ago. With increased time and more sedentary work environments, our society is understandably demanding greater access to more land for outdoor recreation. However, since several species-protection challenges already exist throughout the State due to development, fragmentation, invasive species, altered fire regimes, and climate change, consideration of opening up additional wildlands for recreation presents new challenges to conservation.

Outdoor engagement with natural areas is recognized as a necessary part of people's well-being, yet recreationists are generally attracted to the same high-value open spaces and natural areas that harbor diverse plant and animal communities (Mancini et al. 2018). Accordingly, trails, access points, and associated infrastructure need to be planned and



managed appropriately to complement, rather than diminish, conservation values of lands dedicated to the protection of species and their habitats. In the absence of good planning, recreation-conservation conflicts are increasing, polarizing these two stakeholder groups and eroding their natural affinity and alliance. When conservation and recreation interest groups work together and conservation and recreation lands are planned and managed based on scientific research, a new opportunity emerges for a coordinated approach to protecting California's wildlife while also meeting the demand for high-quality recreational opportunities for diverse user groups.

Recreation and conservation interests would benefit from regular dialogue and collaboration with each other and with federal, state, and local land use authorities regarding regional and local land use planning, acquisitions, and management. A shared, basic understanding of applicable conservation objectives and regulations would provide context and perspective for recreational users and serve to help the two groups work together to ensure each of their interests are served rather than their respective needs being compromised. Without a close alliance among recreation and conservation interests, California risks having insufficient land areas set aside for the thousands of species that depend on California's natural areas, inadequate areas for recreation, and increasing conflicts between conservation and recreation needs. The necessary conversations, research, and determination to collaborate should be embraced and acted upon as soon as possible to help address these needs, reduce the potential for polarization among these stakeholders, and help ensure good land use planning and management decisions are made as development proceeds.

In this essay, we provide an overview of the mechanisms available to implement conservation in California and introduce many of the issues attributed to outdoor recreation when managing for wildlife and natural resources on conservation lands and other public open spaces. We then describe two case studies from our work in southern California that highlight the perceptions and values of outdoor recreationists when visiting conserved lands. The case studies also demonstrate what a successful balance between conservation and recreation uses can look like when moving from conflict to collaboration. We end with a discussion of what is required to achieve that balance and ways to minimize the impacts of outdoor recreation on wildlife and other natural resources.

## CONSERVATION CONTEXT

As California's population grew from a few hundred thousand to nearly 40 million people in less than two hundred years, numerous species' populations have declined. Some, like the iconic grizzly bear (*Ursus arctos horribilis*), are now extinct in the state. Over 450 plant and animal species in California are now listed by the federal or state government as threatened or endangered (CDFW 2019). The cost of species recovery can be enormous, such as the tens of millions of dollars spent to save the majestic California condor (*Gymnogyps californianus*; Walters et al. 2010). To prevent further species declines, a number of laws and regulations exist to avoid, minimize, or compensate for impacts of human activities on species. In California, these include the federal Endangered Species Act (ESA), the California Endangered Species Act (CESA), the National Environmental Policy Act (NEPA), the California Environmental Quality Act (CEQA), among others. Approximately half of California is federally or state-owned lands with a variety of uses, from national forests and state parks to multi-use areas and reserves. In addition to these areas, an appreciable

amount of land is conserved in California as mitigation under ESA, CESA, CEQA, and other laws and regulations.

Successful conservation leads to the protection of species and habitat and the preservation of natural landscapes. Principal types of conservation lands in California include reserves acquired and managed as part of Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs), national parks and monuments, state ecological reserves and wildlife areas, state parks, lands owned by private entities (e.g., land trusts), lands with conservation easements, and mitigation lands. The relative importance of conservation and recreation values to the management goals of these lands vary. For example, state and national parks generally emphasize recreational uses more than mitigation lands and ecological reserves. Sixteen HCP/NCCPs have been approved in California covering part or all of seven counties. Through the new Regional Conservation Investment Strategy (RCIS) Program established in 2017, one RCIS has been approved and an additional eight Regional Conservation Investment Strategies (RCISs) are currently in development or have been submitted for review and approval by the Department of Fish and Wildlife (for more information about RCIS and NCCP programs, see Appendix I). The nine RCISs together will cover part or all of 11 counties. There are also over 130 conservation and mitigation banks in the state, privately held conservation lands, and hundreds of mitigation sites. In total, tens of thousands of acres of habitat have been conserved in California through proactive investments and mitigation. Over one and one-half million acres will be conserved in California under approved HCP/NCCPs, benefiting hundreds of species listed as endangered or threatened under federal and state species protection laws.

## OUTDOOR RECREATION

Millions of Californians and visitors recreate outdoors on natural lands within the state each year (Outdoor Industry Association 2019). Examples of outdoor recreation activities include hiking, trail running, mountain biking, horseback riding, backpacking, camping, and motorized activities. The positive effects of outdoor recreation are numerous. Stewardship values are enhanced. Appreciation of nature is magnified as people are exposed to the inherent beauty, complexity, and serenity of natural systems. The next generation of land stewards and conservationists are born out of the experience of being introduced to wildlands when young. Equally important, the mental health benefits of exposure to the outdoors and participation in nature are now well-recognized (Louv 2005; Thomsen et al. 2018). For a society that is increasingly becoming more urban and digital, the restorative properties of nature and the increased social well-being of individuals and communities is ever more important.

Despite these benefits, the negative effects of recreation on wildlife can be profoundly damaging to species and their habitats and must be considered when planning for conservation areas (Hammit et al. 2015). Trails lead to habitat degradation and fragmentation, which increase when visitors go off-trail and informal trails proliferate. Harassment of wildlife, though often unintended, occurs with increased visitation to an area. Less obvious impacts to wildlife, not easily measured, have been tied to noise, light pollution, trash, and other factors associated with recreation activities.

In general, it can be difficult to accept that recreation activities, especially quiet, non-motorized activities like hiking and mountain biking, can have harmful effects on wildlife. Many types of recreation cause little physical habitat change. Perhaps as a result, recreation

was widely assumed to be a “benign use” that is compatible with conservation goals (Knight and Gutzwiller 1995) and is permitted in the vast majority of protected areas worldwide (Eagles et al. 2002; IUCN and UNEP 2014). Many HCP/NCCPs include a general provision that allows for “low-impact nature trails” without strongly defining what that means and what types and levels of use would be acceptable, given the species that are to be protected. The viewpoint that recreation is a benign use may be changing, however. In recent years, researchers have found evidence that a variety of recreation activities and intensities can have detrimental impacts on wildlife (Geffory et al. 2015; Larson et al. 2016; Samia et al. 2017).

## RECREATION EFFECTS ON WILDLIFE

### Behavior, activity budgets, and physiology

Behavioral reactions, such as flight, flushing, or vigilance are some of the most commonly-observed and studied wildlife responses to recreationists (Larson et al. 2016). Changes in activity budgets have also been observed, with animals typically spending less time in activities such as foraging and caring for young and more time moving or being vigilant when recreationists are present (Schummer and Eddleman 2003; Arlettaz et al. 2015). Physiological responses, such as increases in stress hormones (Arlettaz et al. 2007) or decreased body mass (McGrann et al. 2006), are less obvious to observe, and can occur even when a corresponding behavioral response does not. It is critical not to assume that an animal is tolerant of recreation simply because it does not exhibit a visible response.

### Habitat degradation and fragmentation

Recreation can degrade or fragment habitat, resulting in habitat that is otherwise of high quality being used less frequently or not at all. This is particularly concerning in highly fragmented or developed landscapes where remaining habitat is scarce and there is limited opportunity for wildlife to move to alternative areas. Researchers have observed avoidance of areas used by recreationists in species as diverse as grizzly bears (Coleman et al. 2013), wolverines (*Gulo gulo*; Heinemeyer et al. 2019), caribou (*Rangifer tarandus*; Lesmerises et al. 2018), capercaillie (*Tetrao urogallus*; Coppes et al. 2017), and dolphins (*Tursiops* spp.; Lusseau 2005).

### Reproduction, survival, and abundance

Assessing recreation’s impacts on wildlife population abundance or vital rates can be difficult and time-consuming, and is therefore largely unknown. In one of the few studies of population trends in relation to recreation, Garber and Burger’s long-term study (1995) observed dramatic declines in North American wood turtle populations after the area was opened to recreation. Reproductive success is one of the better-studied population vital rates; negative effects of recreation on reproductive success have been observed in several species including elk (*Cervus canadensis*; Shively et al. 2005), penguins (Giese 1996; Lynch et al. 2010), and plovers (*Charadrius* spp.; Lafferty et al. 2006; Yasué and Dearden 2006). However, other studies have found that habituation can moderate impacts of recreation on reproductive success (Baudains and Lloyd 2007).

## Community composition and richness

Within an ecological community, species respond to recreation differently. This can lead to changes in community composition if more sensitive species avoid areas with recreation or decline in abundance while the habitat use or abundance of tolerant species remains constant or even increases due to reduced competition. When the sensitive species are native and the more tolerant species are non-native, this can lead to dramatic declines of native species as compared to their non-native counterparts (Reed and Merenlender 2008). Overall species richness can also decline if sensitive species disappear from local communities (Bötsch et al. 2018).

## Indirect effects

Recreation can also cause other changes that indirectly affect wildlife, many of which are not well understood. Shifts in diel activity patterns could change the way that species interact with each other or with their environment, potentially leading to increased inter-specific competition during nighttime hours or increased overlap between predators and their prey (Gaynor et al. 2018). Recreation can facilitate the spread of non-native species in freshwater, marine, and terrestrial environments (Anderson et al. 2015), which can have dramatic effects on native wildlife. Recreation activities also often involve infrastructure (e.g., parking lots, maintenance buildings, roads, ski lifts), which can lead to further habitat loss and fragmentation (Nellemann et al. 2010).

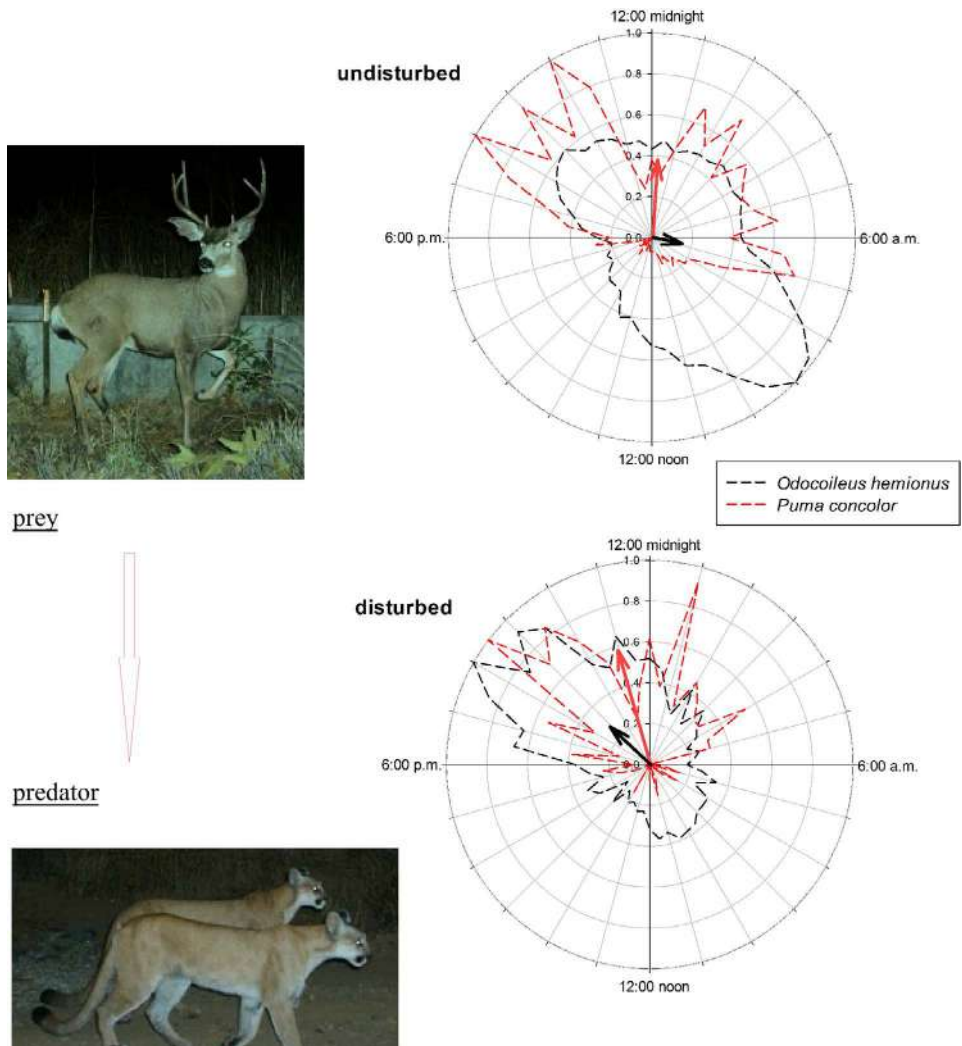
## Examples of recreation impacts from southern California

Examples from southern California, where much of our work occurs, highlight some of the many ways recreation can impact natural resources. Results of ten years of camera-trap studies on conservation lands in Orange County indicate mule deer (*Odocoileus hemionus*) and coyotes (*Canis latrans*) are shifting the timing of activity due to the presence of humans on trails creating novel predator-prey conflicts for wildlife (Patten et al. 2017). Observed shifts toward more nocturnal activity by both species leads to greater temporal overlap in activity periods between mule deer and their principal predator, the mountain lion (*Puma concolor*; Figure 1). Greater overlap between coyotes and gray foxes (*Urocyon cinereoargenteus*) has also been observed, leading to predicted changes in predator-prey dynamics.

Bobcat (*Lynx rufus*) movement modeling using more than ten years of telemetry data in the 7,284-ha South Coast Wilderness of coastal Orange County highlights the importance of maintaining regional connectivity among isolated parcels and continued exclusion of human presence at culverts and other critical linkage points along the coast (Boydston and Tracey 2018). Within landscapes containing natural areas constrained by development, protected habitat and other high-value open space is a premium for wildlife. Providing for safe, unobstructed passage for wildlife among isolated parcels, especially at culverts and other pinch-points, is essential to enable access to high-value habitat within these otherwise constrained landscapes.

In heavily used open space areas, some wildlife appear to develop a tolerance for regular human activity on trails over time. However, patterns of wildlife habitat use can be disrupted by disturbances occurring outside this regular activity, such as large recreation

events, off-trail visitor behavior, or the proliferation of new social trails, even in areas that traditionally see high levels of visitor use. At a local scale, observations of breeding bird behavior before, during, and after a mountain bike race at a wilderness park in Orange County highlights elements of both sides of this phenomenon (Hamilton et al. 2015). In this example, breeding bird behavior continued uninterrupted in areas experiencing similar amounts of activity along the racecourse during the event as to what was experienced prior. As people gathered in numbers on and off the trail at the designated start/end staging area for the event, evidence suggests behavior was disrupted as the sheer volume and continual



**Figure 1.** Diel activity of the mule deer and mountain lion with or without human disturbance. Arrows indicate time (direction) and proportional magnitude (length) of mean activity, and the “net” displays the spread of activity on a 24-h clock, binned at 30-minute intervals. Note the prey’s (the deer) nocturnal shift when disturbance was present. (Figure credit: Patten et al. 2019)

presence of people gathered around the staging area was atypical for this location within the park.

## **CASE STUDY:**

### **UNDERSTANDING VISITOR PERCEPTIONS AND VALUES IN ORANGE COUNTY**

To successfully strike a balance, we need to know more about the human perspective of conservation. By surveying visitors to protected natural areas in southern California over the last couple of years, we learned there is potential for a shared vision of nature protection addressing the needs of both conservationists and outdoor recreationists. Clearly the issues are complex, but with good planning and communication, much can be done to support the creation of a collective vision for compatible conservation and recreation.

Natural Communities Coalition (NCC) is the non-profit management corporation overseeing implementation of the conservation strategy for the County of Orange Central and Coastal Subregion NCCP/HCP. Stretching from the Newport Coast to the Santa Ana Mountains, over 20,200 ha (50,000 acres) of conserved lands together with National Forest are embedded within the conservation plan's 84,000-ha (208,000-acre) planning area. The 75-year plan, signed in 1996, was the first landscape-scale NCCP in the state and one of the first multi-species HCPs nationally.

With 3.2 million residents in Orange County (Center for Demographic Research 2019), the demand for outdoor recreation on lands protected for conservation purposes is ever-present and increasing. Equally important is the recognized need and desire by the community to conserve the rich natural heritage of the southern California region. In Orange County, like in other high-value natural areas of the state experiencing rapid population growth, there is a strong need to strike a balance between conservation and recreation.

Recreation management is one of four main tenets of the regional landscape-level conservation strategy managed by NCC. Recognizing the increasing need to address this topic, NCC staff began focused and meaningful conversations with recreation ecologists and then followed with talking directly to park visitors to understand the human dimensions, that is, the motivations, desires, and values of visitors to the conserved lands. Partnering with Dr. Christopher Monz, Professor of Recreation Resources Management in the Department of Environment and Society at Utah State University, the organization surveyed close to 2,000 visitors in the spring and fall seasons of 2017 and in the spring of 2018 to better understand their perceptions, values, and characteristics (Sisneros-Kidd et al. 2019). In this process, the research team used a theoretical framework that allowed for the identification of internal constructs embedded within visitor questionnaires to reveal motivations and define different user groups. Through the work, two principal groups or clusters of visitors were discovered, those who are motivated most by the opportunity to experience nature immersion and those who are more focused on fitness-based recreation.

Surprisingly, given the urban-proximate setting, and in contrast to the expectations of local land managers, by almost two to one, recreationists were looking to experience nature immersion compared to those seeking fitness-based recreation. These visitors were more motivated by solitude and escape, learning about and experiencing nature, spiritual renewal, and the social experience, versus those in the fitness-based recreation group who

were motivated principally by challenge and outdoor exercise. Learning that the motivation and values of most visitors are more in alignment with resource protection than expected, we had to shift our thinking. Rather than focusing on direct conflict between recreation and conservation, we had to reevaluate how the conversation about balancing recreation and conservation is framed. Knowing it is often the most vocal and well-organized user groups who receive the greatest attention, whether from rangers at a local park or elected officials at a public meeting, we recognized it was of value for decision-makers to be informed of the findings and equally consider the motivations, values, and desires of the quiet majority in these public spaces and forums.

Digging deeper into the results of the work, we found people largely recognize the value of habitat and natural resource conservation; however, they too want to be part of the story. People do not want to be left “standing on the sidelines or looking over the fence;” they want to experience the rich natural resources that make California so unique. When asked how satisfied they were in their ability to achieve a variety of experiences during their visit to a park, visitors reported they were often left wanting more when it came to learning about nature and becoming more in touch with their spiritual values.

Visitor responses indicated they experience place attachment. When asked, they recognize the lands upon which they choose to regularly recreate are not necessarily unique relative to other protected areas. However, to them these lands and parks are special, meaningful, and important. Place attachment may be reflected in the high repeat visitation rates of visitors. More than half of those surveyed visited parks more than 50 times within the same year. Furthermore, many of the visitors live within neighboring communities. For almost half of the parks included in the study, more than 25% of visitors live within 3 miles of an entrance location (Mitrovich, unpublished data). To these people, the parks are a recognized and utilized part of their local community’s resources.

Recreation is multidimensional and multifaceted, and we recognize a more sophisticated approach to finding solutions is warranted when seeking to minimize recreational impacts on sensitive natural resources. Impacts and motivations vary by user group, as does the attractiveness of different topography. From the surveys, we learned mountain bikers look to avoid crowds, are most knowledgeable about “leave no trace,” most interested in more trails, and most likely of all user groups to be satisfied in their ability to get away from the demands of life when out on trails. Dog walkers, on the other hand, were least knowledgeable about “leave no trace,” most avoided by other recreational groups, and least satisfied in their park experiences as it relates to their ability to learn more about plants and animals. Some hikers and runners were concerned about the number of mountain bikers they encountered in particular parks and along certain trails. Different topographic features attracted different users. Steep trails that offer high speeds and technical challenges are attractive to mountain bikers but can be off-putting to other user groups. In unregulated spaces popular with the masses and advertised through social media, trails can be degraded and spider, further fragmenting and degrading available habitat. The overlap between areas used for recreation and high-value wildlife habitat may be greatest with nature-based recreationists.

One positive take-home, as we look for solutions, is that visitors in urban landscapes are much more tolerant of crowded conditions than previously recognized by land managers. Parks in Orange County have seen a dramatic increase in use over the last decade, with increases of greater than 50% not uncommon over a 4-year period (Monz et al. 2019). However, at many parks considered to be “crowded” by land managers, over 80% of re-

spondents surveyed did not feel the presence of other people on the trail interfered with their activities or made them feel rushed or slowed them down during their visit. Equally, over 80% of respondents in 2018 did not feel the number of people at the park increased their risk of injury.

Although many folks are comfortable in a more crowded space, not everyone is comfortable with the changing dynamics and increases in observed use experienced over the last decade. Across both before-mentioned measures, there were respondents that felt the number of people at the park during their visit did increase their risk of injury at least some of the time, and other visitors and their activities interfered with their visit. Like wildlife, it appears people's tolerance of novel conditions is not fully universal and may differ across generations, by past experiences, and expectations (Shelby et al. 1983). When coupled with their understanding that off-trail activity is most impactful, the general tolerance of folks to increased visitation rates gives hope as we look for solutions to meeting increased demand while paying the necessary attention to detail to create the recreational opportunities valued by most that continue to honor the shared commitment and need for lasting conservation.

## CASE STUDY:

### CONFLICT TO COLLABORATION IN THE COACHELLA VALLEY

Now we turn to one example of how a region is addressing the question, what to do when trail users and sensitive species like the same habitat? Like other areas of southern California, the Coachella Valley in the desert and mountain regions of eastern Riverside County has seen a remarkable increase in the demand for outdoor recreation on trails, especially hiking and mountain biking. In this desert resort area, land of more than 100 lush golf courses, demand for golf is flat, while hiking has surged in popularity, in large part due to the influence of social media.

In 2008, the California Department of Fish and Wildlife (CDFW) and the U.S. Fish and Wildlife Service (USFWS) approved the Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVNCCP) with a 75-year permit. Like other efforts in California and beyond, it was a visionary effort to balance conservation and development. The plan encompasses an area of almost 500,000 ha (1.1 million acres) from Palm Springs to the Salton Sea and beyond. Implementation of the plan is overseen by the Coachella Valley Conservation Commission (CVCC), made up of elected officials from participating cities, Riverside County, local water districts, and other agencies.

However, several years earlier, the conflict between trail users and agency biologists nearly derailed the CVNCCP. During development of the plan, proposals by state and federal wildlife agencies to impose seasonal closures on some trails galvanized trail users to organize and turn out in large numbers at public hearings. The proposal to close trails centered on concerns about the impacts of trail use on Peninsular bighorn sheep (*Ovis canadensis nelsoni*), a state and federally listed endangered species (Figure 2). In response, trail users read scientific literature, interviewed bighorn sheep biologists, and questioned the scientific basis of the trail restrictions. They used their newfound knowledge and spoke passionately about their concerns to elected officials, often quoting published scientists.

When the CVNCCP was approved in 2008, it did not include the trail closures that had been envisioned. Public input from trail users convinced decision-makers to avoid these measures. It also convinced conservation planners that a full trails management plan needed



to be developed for the CVNCCP. Unfortunately, the process also left trail users alienated and with a lack of trust in the state and federal wildlife agencies. Wildlife agencies were suspicious of trail users' motivations. It would be years before these attitudes changed. Trail users seeking nature immersion, who could have been a natural constituency for support of the conservation proposed by the CVNCCP, continued to question the scientific basis of the trails plan. Even after the CVNCCP was completed and fully permitted, the lack of trust remained.

To provide a forum for input from trail users and local governments, the final CVNCCP called for formation of a Trails Management Subcommittee, composed of a representative from each of nine cities involved in the CVNCCP, the Agua Caliente Band of Cahuilla In-



**Figure 2.** In some areas of the Santa Rosa and San Jacinto Mountains National Monument, seasonal trail closures are in place to allow bighorn sheep and other wildlife access to waterholes during the hot summer months. (Photo credit: CDFW)

dians, trail user groups (mountain bikers, hikers, equestrians), environmentalists, biologists from CDFW, USFWS, Bureau of Land Management, and other land management agencies. The group was charged with providing recommendations on trails management, annually reviewing the status of bighorn sheep, and communicating trails-related information to stakeholders. Their tasks required them to develop a shared understanding of relevant conservation objectives and regulations while they worked together to accomplish their charge.

A dedicated group of volunteers, the subcommittee took their responsibility seriously and worked hard. Meetings were well attended and often animated. Passions flared, and sometimes sparks flew. On occasion, meetings devolved and became acrimonious and full of

conflict. Trail users continued to question the scientific basis for trails management actions proposed by “the agencies.” Agency biologists doubted the trail users’ commitment to the protection of bighorn sheep and were reluctant to share data. Unfortunately, throughout the process, scientifically rigorous data on the effects of trail use on bighorn sheep was limited. The studies needed to understand the relationship between trail use and bighorn sheep had not been done. The CVNCCP was approved in 2008, the year the recession hit and resources for local, state, and federal agencies were further limited by lack of funding.

In 2011, the conflict between recreation and habitat ended up in the state legislature when CDFW closed the upper portion of the very popular Bump and Grind Trail to protect bighorn sheep. Though not a trail which offers the experience of solitude, the Bump and Grind provides a great cardio workout, with hikers numbering more than 1,000 some days. Questioning whether any studies to prove that hikers have an impact on the endangered bighorn had been presented, trail users went to their state legislators. Ultimately, a compromise was worked out and Governor Brown signed legislation in October 2013. The upper Bump and Grind is now closed for three months during the sensitive bighorn sheep lambing season, from February through April, and open for the remaining nine months of each year. The Coachella Valley Conservation Commission worked with CDFW to install a fence to discourage off-trail travel and educational signs about bighorn sheep.

Despite the challenges, the Trails Management Subcommittee persevered. They worked through the challenges, developed more trust, and learned to work together. They completed an update to the 2008 Trails Management Plan in 2014. The updated plan emphasizes the adaptive management approach described in the CVNCCP. It calls for research on the relationship between bighorn sheep habitat use and trail use, prior to construction of new trails. Technology has made such research more feasible, especially in the rugged and remote terrain of the Santa Rosa and San Jacinto Mountains National Monument. Since 2015, GPS collars have been placed on bighorn sheep, providing data on their movements and habitat use. The CVCC is now working on a study of bighorn sheep and trails, led by Dr. Kathleen Longshore of the U.S. Geological Survey and funded by a grant from CDFW. The trails subcommittee is actively involved with researchers in the development of the study protocol and review of all data. Field work began in fall 2019, with volunteers collecting data on recreational trail use and researchers comparing the human use data with bighorn sheep collar data.

Conflict has been replaced with collaboration. Although all of the best practices were not used initially, when they were used, they became lessons learned. If people understand why, they are more likely to go along with regulations (Marion and Reid 2007). Furthermore, when the need for regulation or constraints are understood, constraints can become a positive as they provide the basis for best practices and assure access via responsible use.

## **WHAT IS NEEDED TO ACHIEVE BALANCE? WHAT WORKS?**

Several land management decisions are being made today with long-term implications for the state of biodiversity and human wellness within California. Without collaboration among recreation and conservation interests, California risks insufficient lands being set aside for the benefit of protecting species, insufficient lands for recreating, and poorly located lands for both purposes, with people and other species suffering the consequences. Recreation and conservation stakeholders need to talk and work with each other and with

ecologists and land planners early and often in the regional visioning and land planning process to ensure both interests get what is needed in a way that strikes a balance for species and habitat protection, and people's access to the outdoors.

To achieve a better land use future for conservation and recreation outcomes, we recommend early investment in working relationships. Increased early communication among all stakeholders, land planners, and managers, together with basing decisions on the best available science, can help reduce land use conflicts, the loss of species, and lower-quality recreation experiences. Groups should accept there will be situations when they collectively agree to disagree. However, the long-term commitment to work together will increase the likelihood of achieving goals and objectives for all interests. Most land conserved through public funding sources and/or mitigation and all HCP and NCCP properties have some form of Resource Management Plan (RMP) and/or Conservation Easement attached to them. It is critical RMP's are developed with a "clean slate" to identify critical sensitive species, regional context, and wildlife linkages up front. This, in turn, identifies potential areas appropriate for trails and other recreational uses, thus reducing debate and conflict later.

We also recommend establishing appropriate monitoring programs that are used to evaluate conservation and recreation outcomes and modify management plans to better achieve the original goals and adjust to changing conditions. The wide variety of nature-based recreational activities, timing and frequency of those activities, and numbers of people that participate in them, all result in a complex array of potential effects. Adding to that is the complexity of behavioral responses and sensitivities of different species to those activities. Recognizing this complexity and planning according to research findings that are available, and the anticipated growth or other changes expected, can help planners create conservation areas and recreation areas positioned to avoid future conflicts.

Opportunities to be inclusive and reach out to stakeholders as partners in the long-term management of protected lands are numerous. By simply involving everyone up-front, community members can be engaged early in the planning process and contribute to the search for solutions. Volunteers can help to enforce site rules using peer pressure. They may also be able to help with site maintenance, monitoring, and identification of possible management actions, such as when monitoring information indicates a problem exists. An open phone line to land managers is essential and over time naturally builds relationship and trust.

### **How can effects be minimized?**

Using good science in the decision-making process is key, as is making data transparent and remembering the importance of educating the public throughout the process. Planning efforts should search for and incorporate relevant scientific findings. Despite the variability in species responses to different types and intensities of recreation, researchers have identified some ways to minimize the effects of recreation on wildlife:

- Monitor and prevent unauthorized trail creation and off-trail use. Many animal species respond more strongly to recreationists in unexpected places, such as off-trail (Stankowich 2008; Heinemeyer et al. 2019), so increasing the predictability of human presence by constraining people to the existing trail network may help mitigate negative effects.
- Limit nighttime access to parks and trails. Since people are primarily active during the daytime, many animal species avoid interactions with people by increasing the proportion of their activity that takes place at night (Gaynor et al. 2018). While the

implications of this shift for foraging success and interspecific interactions are largely unknown, limiting activity to daytime hours may be a way for humans and wildlife to coexist in parks and natural areas. Nighttime recreation is growing in popularity but may prevent animals from temporally avoiding people, and should be limited in general, and probably all together avoided in urban-proximate wildland areas where the existence of refugia is already severely limited spatially.

- Leave areas without trails, both within individual properties and at landscape scale. For the most part, research has not yet identified ‘safe’ levels of human activity that result in minimal negative outcomes for wildlife. Some species appear to respond to very low levels of human activity and would benefit from blocks of trail-free habitat; in one example, mountain lions, coyotes, and bobcats increased nighttime activity and decreased daytime activity in locations with levels of use as low as two people per day (Wang et al. 2015).
- Plan access points and infrastructure carefully. Parking lots and other facilities can increase the level of use at corresponding trails (Larson et al. 2018). On the other hand, a lack of parking space at popular trails can result in public safety issues if visitors park along busy roadways. Improper parking can also impact habitat, which can cascade to impact wildlife as well.
- Use seasonal trail closures during sensitive periods. For many species, the most sensitive period is the breeding period, when disturbance can lead to reduced reproductive success (Bötsch et al. 2017), which in turn can result in population declines.
- Collect visitor use data. Without some knowledge of the intensity and distribution of recreational use, it is difficult for managers to know where and when impacts on sensitive wildlife species may be occurring. Monitoring equipment can be costly to purchase and maintain, but basic measures like periodic manual counts at parking lots or trailheads can be helpful in tracking trends, and there are promising emerging approaches using information that visitors share on social media platforms, mobile devices, and fitness applications (Fisher et al. 2018; Monz et al. 2019; Norman et al. 2019).
- Consider diverse visitor perspectives and values. Employ contemporary scientific approaches so key components in the human dimension of recreation (e.g., perceptions, characteristics, and motivations) can be understood more formally and inform a planning process for long-term sustainable use.
- Determine thresholds of acceptability of key indicators of resource and social conditions. Recognize “carrying capacities” exist for protected lands and their identification is a key component in the planning process and essential to developing a range of possible management actions, from the spatial and temporal separation of different types of recreational uses to acceptance and identification of high and low intensity use areas within the greater protected open space network.

An opportunity is emerging to expand upon local successes and encourage a new dialogue among agencies, conservationists, and recreationists, both at the local level and regionally, in support of the expanded protection of natural lands throughout California. We encourage interested parties to continue to learn more about the use of conservation planning tools and visitor use management made available through the CDFW and USFWS, and Interagency Visitor Use Management Council (Appendix I). Forming partnerships allows stakeholder groups to work together to plan ahead of growth and build regional conservation

strategies for the increased protection of natural lands, addressing the long-term conservation needs of California's natural resources and the strong desire of people to experience nature.

### ACKNOWLEDGMENTS

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## **APPENDIX I: AVAILABLE CONSERVATION PLANNING AND VISITOR USE MANAGEMENT TOOLS**

### **Natural Community Conservation Planning**

The Natural Community Conservation Planning (NCCP) Program promotes collaborative planning efforts designed to provide for the region-wide conservation of plants, animals, and their habitats, while allowing for compatible and appropriate economic activity. <https://www.wildlife.ca.gov/Conservation/Planing/NCCP>

### **Regional Conservation Investment Strategy Program**

The Regional Conservation Investment Strategy (RCIS) Program encourages a voluntary, non-regulatory regional planning process intended to result in high-quality conservation outcomes. The Program consists of three components: regional conservation assessments (RCAs), regional conservation investment strategies (RCISs), and mitigation credit agreements (MCAs). <https://www.wildlife.ca.gov/Conservation/Planning/Regional-Conservation>

### **Conservation and Mitigation Banking**

Conservation and mitigation banking in California is overseen and undertaken by several Federal and State Agencies. The Banking Program coordinates with other agencies and stakeholders to develop statewide policy and guidance for the establishment and operation of conservation and mitigation banks. <https://www.wildlife.ca.gov/Conservation/Planning/Banking>

### **Biogeographic Information and Observation System (BIOS)**

BIOS is a system designed to enable the management, visualization, and analysis of biogeographic data collected by the California Department of Fish and Wildlife and its Partner Organizations. <https://www.wildlife.ca.gov/Data/BIOS>

### **Areas of Conservation Emphasis (ACE)**

ACE is a CDFW effort to analyze large amounts of map-based data in a targeted, strategic way, and expressed visually, so decisions can be informed around important goals like conservation of biodiversity, habitat connectivity, and climate change resiliency. <https://www.wildlife.ca.gov/Data/Analysis/Ace>

### **Visitor Use Management (VUM) Framework**

VUM is a toolbox for visitor use management and addresses conservation issues. The framework also includes topic areas like capacity, indicators and thresholds, as well as the importance for monitoring recreation use. <https://visitorusemanagement.nps.gov/VUM/Framework>

## **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**

ELIZABETH LUCAS\*

California Department of Fish and Wildlife, Region 5, Natural Community Conservation Planning Program, San Diego, CA 92123, USA (Retired)

\*Corresponding Author: libbylucas5@gmail.com

Expanding levels of authorized and unauthorized non-consumptive recreation increasingly threaten sensitive biological resources in areas protected primarily or solely to conserve them. As California's human population grows, recreational use in protected areas grows commensurately. The majority of the documented effects on wildlife from non-consumptive recreation are negative; they include detrimental changes in behavior, reproduction, growth, immune system function, levels of stress hormones, and finally, to the survival of individual animals and persistence of wildlife populations and communities. This paper provides insights from the recreation ecology literature into these recreation-related disturbances to insects, amphibians, reptiles, birds, and mammals from hiking, jogging, biking, horseback riding, boating, and off-highway/all-terrain vehicles. The documented evidence of these disturbances to wildlife reveals the flaw in the prevalent assumption that recreation is compatible with biological conservation, the dual-role protected areas' core function. This assumption usually rests on the expectations of (1) allowing only ecologically sound siting of recreational areas and ecologically acceptable types, levels, and timing of recreation, and (2) providing sufficient monitoring, management, and enforcement of recreation to ensure the perpetuation of viable populations of focal sensitive species. However, it is rare that these expectations are met. The ultimate essential outcome of the information provided in this paper is the cessation of the extant recreation-related exploitation of dual-role protected areas. This calls for a societal course change involving: widespread, long-term, and continual multimedia dissemination of the science-based information about recreation-related disturbance to wildlife; application of a science-based approach to siting recreational areas and allowing only ecologically acceptable types, levels, and timing of recreation; and, perpetual personnel and funding explicitly for management at levels commensurate with recreational pressure. These measures would also improve the often cited economic, educational, and recreational/health benefits of dual-role protected areas.

Key words: dual-role protected areas, enforcement, fragmentation, management, multimedia education, non-consumptive recreation, perpetual funding, planning and siting of trail networks, recreational disturbance to wildlife, unauthorized trails

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Conserving habitats is a key strategy for conserving biodiversity worldwide (Pickering 2010). In California, the core function of many areas protected for conservation is to ensure the perpetuation of sensitive species (i.e., species whose persistence is jeopardized), as is appropriate for the nation's most biologically diverse state (CDFW 2015). The level of land conservation that California enjoys is intended to ensure that the state's globally renowned biodiversity remains intact. However, of all the states in the USA, California hosts the most listed species imperiled by recreation, in part because the strongest association of outdoor recreation is with urbanization (Czech et al. 2000), which is itself an important cause of endangerment (Reed et al. 2014). The anticipated growth of the state's human population from approximately 38 million in 2013 to 50 million by mid-century with a commensurate increase in recreational demands in protected areas will likely increase the continual challenge of conserving the state's wildlife (CDFW 2015).<sup>1,2</sup> The dual role of protected areas to conserve biodiversity and provide nature-based recreational and educational opportunities for millions of people rests on the assumption that non-consumptive recreation is compatible with wildlife conservation, despite documented evidence to the contrary (Reed and Merenlender 2008; Larson et al. 2016; Hennings 2017; Dertien et al. 2018; Reed et al. 2019).<sup>3</sup> Ecologically sound types, levels, timing, and siting of recreation, and perpetual management of recreation at or exceeding a level commensurate with the recreational pressure, are vital to ensure the perpetuation of viable populations of focal sensitive species in "dual-role" protected areas.<sup>4,5</sup>

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<sup>1</sup> Protected areas include locally-owned lands (e.g., county and city reserves), state-owned lands (e.g., ecological reserves, wildlife areas, state parks), federally owned lands (e.g., national wildlife refuges, wilderness areas), and privately owned lands (e.g., conservation easements, conservancy lands, mitigation banks and lands). Here, the focus is on protected areas preserved primarily or solely for the perpetuation of sensitive species (e.g., ecological reserves, protected areas established pursuant to Natural Community Conservation Plans and/or Habitat Conservation Plans, mitigation banks and lands).

<sup>2</sup> Wildlife means all wild animals: insects, fish, amphibians, reptiles, birds, and mammals.

<sup>3</sup> In contrast to consumptive recreation (e.g., hunting, fishing), non-consumptive recreation is generally assumed not to directly extract a resource; it includes nature and wildlife viewing, beach-going, kayaking, hiking, biking, horseback riding, and wildlife photography (Reed and Merenlender 2008; CDFW 2016; Gutzwiller et al. 2017). From here forward, "recreation" means non-consumptive recreation, unless otherwise stated.

<sup>4</sup> Focal species are organisms whose requirements for survival represent factors important to maintaining ecologically healthy conditions; identified for the purpose of guiding the planning and management of protected areas in a tractable way, focal species include keystone species, umbrella species, flagship species, and indicator species (Soulé and Noss 1998; Marcot and Flather 2007). Here, the term "focal species" is intended to include those species encompassed by the guild surrogate approach of conservation; this approach entails one member or a subset of members serving as a surrogate for other members of the guild (Marcot and Flather 2007).

<sup>5</sup> From here forward, "management" includes monitoring, management, and enforcement with the necessary authority. The level of enforcement necessary is dependent on the level of continual management implemented; generally, the more the management, the less enforcement is necessary. In addition, monitoring and management encompass both the natural resources and human users of the protected areas. The fiscal support to be secured includes personnel and all program costs.

## Insights from studies

*Purpose.*—The purpose of the following discussion is to provide insights to disturbances to several wildlife species from non-consumptive recreation. Accordingly, the insights are exclusively from studies that document recreation-related disturbance to wildlife. This approach reflects the evidence that the majority of documented responses of wildlife species to non-consumptive recreation are negative, as demonstrated in two systematic literature reviews (Reed et al. 2014; Larson et al. 2016) and a literature review of over 500 articles written and reviewed by the scientific community (Hennings 2017). The insights are intended to (1) illustrate that scientific studies provide clear evidence of recreation-related disturbance to wildlife, (2) elicit awareness of and concern about the disturbance, and (3) stimulate action to address it.

*Sources and scope.*—The 71 articles and 13 reports<sup>6</sup> reviewed about the recreation-related effects on wildlife generally reflect Larson et al.'s (2016) finding that studies about such effects focus on mammals (42%) and birds (37%), followed by invertebrates (12.4%), reptiles (5.5%), fish (5.1%), and amphibians (0.7%); there are no insights herein from studies of fish. Larson et al. (2016) found that some of the least-studied taxonomic groups (i.e., reptiles, amphibians, and invertebrates) had the greatest evidence for negative effects of recreation. While not all the studies selected for this paper address wildlife in California, all the studies' scenarios could occur in the state as do all species types among the studied taxa (i.e., insect, amphibian, reptile, bird, mammal).

Not all of the studies selected for this paper address sensitive species. This is primarily because current research on recreation-related effects on wildlife includes few species of conservation concern (Larson et al. 2016). However, sensitive species may experience greater levels of recreation-related disturbance than described for common species in the study insights herein. This is because many rare and isolated species are specialists, and they may be more sensitive to anthropogenic disturbance, including recreational activities, than common and widely distributed species (Bennett et al. 2013; Reilly et al. 2017). Recreation-related declines of common species warrant attention because of their functional ecological importance – local depletions of common species can have broad consequences within the food web (Säterberg et al. 2013; Baker et al. 2018; Reed et al. 2019). Recreation-related declines or disturbance in an important common prey species may affect the species in higher trophic levels (Reed et al. 2019). More than a quarter of species become functionally extinct before losing 30% of their individuals (Säterberg et al. 2013; Baker et al. 2018; Reed et al. 2019); here, functional extinction occurs when the population size of the depleted species is below the level at which another species goes extinct (Baker et al. 2018).

The scope of this paper does not include studies about snow-based recreation, though all of the 14 articles addressing snow-based recreation that Larsen et al. reviewed reveal that non-motorized and motorized snow-based activities (i.e., skiing, snowshoeing, snowmobiling) can have significant negative effects. Nor does the scope of this paper include studies exclusively about the effects of dogs on wildlife; however, a literature review on the effects of dogs on wildlife concludes that (1) people with dogs on leash, and even moreso

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<sup>6</sup> All the articles are published in peer-reviewed journals. Some of the reports were peer reviewed and all were written by or contributed to by professionals in the fields of biology or ecology, though none of the reports were published in peer-reviewed journals to this author's knowledge (e.g., Burger 2012; Hennings 2017; Dertien et al. 2018; Reed et al. 2019). This paper does not cite all the articles and reports this author read. And, the totals exclude documents that are not explicitly about recreation-related effects on wildlife (e.g., Tinkler et al. 2019; Taff et al. 2019; Wolf et al. 2019) and all newspaper articles.

off leash, are more alarming and detrimental to wildlife than any non-motorized recreational user group without dogs, and (2) people with dogs substantially increase the amount of wildlife habitat affected (Hennings 2016). Hennings (2016) also asserts that wildlife does not appear to habituate to the presence of dogs; effects linger after dogs are gone because the scent of dogs repels wildlife.

*Management measures.*—The study insights focus on the documented recreation-related disturbance to wildlife, not on management measures to prevent or minimize the disturbance. However, many of the reviewed articles and reports identify such measures, which range from full prohibition of human access, to time-of-access restrictions (e.g., seasonal or diurnal/nocturnal restrictions), to various measures based on disturbance thresholds. Disturbance thresholds are thresholds of various measurable parameters above or below (depending on the parameter) which wildlife is disturbed. Examples of disturbance thresholds are distance between trails and nesting sites, density of active trails, number of recreationists, number of recreational events per time frame, and duration of recreation. These thresholds may be used to establish management measures such as minimum widths of spatial buffers between recreational trails and wildlife.

A common theme among the management measures is that continual proactive and adaptive management is needed to protect wildlife from recreational disturbance, and that access closures should occur if the management fails.<sup>7</sup> Adaptive management is a cornerstone of large-scale multi-species conservation (CDFW 2014). An example of proposed management measures is Dertien et al.'s (2018) recommendation for a precautionary approach that adopts maximum values of quantitative disturbance thresholds observed for the taxa of concern, while excluding the extreme values of the thresholds.<sup>8</sup> This approach stems from the gaps in knowledge about quantitative disturbance thresholds of recreation; such thresholds are lacking for many species, taxonomic groups, and sources of disturbance.

Regarding spatial buffers, a general rule of minimum thresholds for distance to trails cannot be established for some species, as individual variability within species can be high and can differ among populations, types of topography, and frequencies and types of human intrusion (González et al. 2006). For example, Dertien et al. (2018) recommended a 200-m minimum buffer for ungulates; however, this would be insufficient for the circumstances of Taylor and Knight's (2003) study further cited below in which they found that mule deer (*Odocoileus hemionus*) showed a 96% probability of flushing within 100 m of recreationists located off trails, and the probability of their flushing did not drop to 70% until perpendicular distance reached 390 m. Two additional factors that influence the determination of spatial buffers are "effect zones" (i.e., areas within which wildlife is disturbed by recreational ac-

<sup>7</sup> Based on section 13.5 of the California Fish and Game Code and the Natural Community Conservation Planning Act (i.e., section 2805 of Fish and Game Code), adaptive management generally means (1) improving management of biological resources over time by using new information gathered through monitoring, evaluation, and other credible sources as they become available, and (2) adjusting management strategies and practices accordingly to assist in meeting conservation and management goals (e.g., conservation of covered or focal species). Under adaptive management, program actions are viewed as tools for learning and to inform future actions.

<sup>8</sup> The central tenet behind the precautionary principle is that precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. Generally, the four central components of the principle are: taking preventive action in the face of uncertainty; shifting the burden of proof to the proponents of an activity; exploring a wide range of alternatives to possibly harmful actions; and increasing public participation in decision making (Kriebel et al. 2001). There are subtle differences between the precautionary principle and precautionary approach, but their consideration is beyond the scope of this paper.

tivities on trails) and the density of the trail networks. The effect zones can extend several hundred meters on either side of the trails (Reed et al. 2019). The smaller a protected area is and the denser its trail networks are, the greater the proportion of the protected area is occupied by effect zones, and the less likely it is that spatial buffers such as those Dertien et al. (2018) recommended will protect the focal species from recreational disturbance (Wilcove et al. 1986; Ballantyne et al. 2014).

There are many sources that provide information about management of recreation in protected areas, or guidance on the design or siting of trails/trail networks. These sources include management framework tools designed to address recreational use, though they vary in their attention to the needs of wildlife (Hennings 2017).

## Insects

In a study of the effects of walkers, runners, and runners with dogs on the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*; Karners) at the Indiana Dunes National Lakeshore, USA, Bennett et al. (2013) found that (1) Karners flushed in the presence of recreationists as they would respond to natural agents, such as predators; (2) recreation restricted host-plant choice by reducing host-plant availability, effectively rendering the quality of habitat within 10 m of the trail unsuitable; (3) recreation had the potential to reduce oviposition rate of virtual females by 50%, and therefore population growth rates; (4) the frequency at which recreationists negatively affected the females (including their oviposition) varied substantially with habitat extent, number of recreationists, and sensitivity; and (5) habitat extent was the primary predictor variable. The authors concluded that Karners will experience less recreation-related disturbance the farther their habitat extends beyond trails.

In a study conducted near Palo Alto, California, USA focusing on 10 native oak woodland species of butterflies, Blair and Launer (1997) 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. The authors also concluded that multi-use areas may not adequately preserve butterfly species diversity.

## Herpetofauna

*Responses of the Iberian frog to recreational activities.*—In a study involving field research in the Guadarrama Mountains in central Spain and simulation modelling to assess the effects of recreation on Iberian frogs (*Rana iberica*), an endemic species in decline, Rodríguez-Prieto and Fernández-Juricic (2005) measured frog abundance and response to human disturbance. The authors found that Iberian frog abundance (a population-level parameter): (1) was significantly affected mainly by study site location and distance to the nearest recreational area, a proxy for human disturbance; (2) was positively related to distance from recreational area (i.e., as distance decreased, abundance decreased); and (3) increased as number of humans decreased. With respect to the effects of repeated disturbances (e.g., human approaching with a steady pace) on the individual-level parameters of

flight initiation distance<sup>9</sup> and time to resume pre-disturbance activities, the study showed that: (1) frogs' flight initiation distances were longer in areas with less vegetation cover; (2) though the flight initiation distances did not vary with repeated human approaches, the number of repeated human approaches affected the frogs' time to resume pre-disturbance activities, with second and third approaches increasing the time it took frogs to reoccupy the disturbed spot; and (3) there was an 80% decrease in the frogs' stream-bank use with a 5-fold increase in the direct disturbances per hour, and a 100% decrease in stream bank use with a 12-fold increase in human disturbances per hour. The authors concluded that direct human disturbance affects this species at the population level, and that it needs to be considered as a potential factor affecting amphibian populations with low tolerance for disturbance.

*Responses of the yellow-blotched turtle to human disturbance.*—In a study along a 300-m reach of the Pascagoula River in southeastern Mississippi, USA, Moore and Siegel (2006) studied the effects from boating, fishing, jet skis, and direct anthropogenic damage to nests on the nesting and basking behavior of the yellow-blotched map turtle (*Graptemys flavimaculata*), listed as threatened under the U.S. Endangered Species Act. With respect to human disturbance of nesting turtles, the authors found that numerous turtles waited several hours near a sandbar before emerging from the water onto the beach to nest, and turtles that attempted to nest upon emerging onto the beach frequently abandoned their efforts and retreated to the water—of a total of 79 nesting attempts, only 15 successfully completed oviposition. With respect to human disturbance of basking turtles, the authors found that the number of turtles disturbed differed significantly with the type of disturbance; specifically, anglers that remained in the basking vicinity caused the most disturbance, and jet-skis caused less than an expected amount of disturbance; this was likely because of the anglers' closeness (compared to the jet-skis) to the basking logs and the long periods they remained, both of which caused turtles to bask less. Moore and Siegel (2006) concluded that: the interruption of nesting activities may have a severe impact on the viability of this population of turtles through changes in numbers of clutches; and, the interruption of basking and consequent reduction in the turtles' body temperature has the potential to negatively affect the ability of all turtles to process and digest food, and the ability of females to develop eggs during the reproductive seasons.

*Responses of the common wall lizard to tourism.*—In a study of common wall lizards (*Podarcis muralis*) conducted in areas with high and low levels of tourism within the same habitat in the Guadarrama Mountains in central Spain, Amo et al. (2006) examined whether the lizards differed in several parameters upon each human approach. The authors found that: (1) regardless of the level of tourism, lizards usually exhibited anti-predator behavior by fleeing to hide in refuges upon approach of a human; (2) in comparison to lizards inhabiting areas of low tourism pressure, lizards inhabiting areas with high tourism pressure, and therefore presumably escaping to hide in refuges more often, showed a poorer body condition and higher intensity of tick infection at the end of the breeding period; and (3) the intensity of tick infection was higher in male than in female lizards. The authors speculated that the higher intensity of infection probably resulted from the cumulative costs of high frequency of flight, since anti-predatory behaviors such as flight are costly in terms of losing time for other activities, including feeding—nutritional status can affect the capacity

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<sup>9</sup> The flight initiation distance is the distance from an approaching threat (e.g., recreationist) at which an animal initiates moving away to escape from the threat. This movement is a fitness/energy cost to the fleeing animal. For the Iberian frogs, this was the distance between an approaching human and the frog when the latter jumped into the water in response to the human's approach.

of lizards to mount an immune response to infection. Furthermore, lizards with poor body condition had low levels of immune response, which may aggravate the deleterious effects of anti-predatory behavior on body condition. Female lizards in poor body condition produced offspring of small size, and body size of infant lizards can affect their probability of survival. Additionally, females with blood parasites also showed reduced fat stores and produced smaller clutches. By these effects on infants and clutch sizes, tourism may also negatively affect the maintenance of lizards' populations.

*Responses of various reptiles to recreationists.*—In a study to systematically assess recreationists' direct and indirect effects on sensitive wildlife species in 14 NCCP/HCP protected areas in San Diego County, California, USA, Reed et al. (2019) integrated monitoring of both wildlife species and recreationists (e.g., hikers, mountain biker, horseback riders).<sup>10</sup> The authors found that recreation was associated with declines in reptilian species' richness, occupancy, habitat use, and relative activity in the NCCP/HCP protected areas. Of the three species (all lizards) for which statistical analyses were feasible, two exhibited negative relationships between occupancy and human recreation—the orange-throated whiptail (*Aspidoscelis hyperythra beldingi*, an NCCP/HCP-covered species) and common side-blotched lizard (*Uta stansburiana*).

## Birds

*General responses.*—In Steven et al.'s (2011) review of 69 peer-reviewed articles (50 of which were research conducted in protected areas) of original research on the effects on birds from non-motorized nature-based recreation, 61 articles reported recreation as having negative effects (i.e., negative changes in physiology, behavior, abundance, and reproductive success, the latter including the number of nests, eggs laid, and/or chicks hatched or fledged). The single documented positive effect involved an increase in the abundance of corvids (e.g., crows and ravens) in campgrounds. Walking or hiking, standing or observing birds from viewing platforms or standing next to a nesting colony, dog walking, running, cycling/mountain biking, and canoeing were all reported as negatively affecting birds. A large majority (85–93 %) of the studies that examined the effects of a single person, groups of two or more people, and/or avian population-level responses, reported negative effects. The population-level responses entailed effects on density, abundance, and reproduction.

In a study using data collected in 112 urban parks throughout Melbourne, Australia, Bernard et al. (2018) tested whether birds responded differently to bikers and walkers. They found that: (1) relative to their response to walkers, four of the 12 focal species studied initiated escape from bikers at longer flight initiation distances and two escaped with greater intensity (i.e., more likely to involve flying); (2) no species responded less to bicycles than to walkers; and (3) the flight initiation distance did not differ in response to speed of bicycle travel, though the difference in the two speeds used was only 1 m/sec. In concluding that

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<sup>10</sup> An NCCP (Natural Community Conservation Plan) is a comprehensive, single- or multi-jurisdictional/utility plan that provides for regional habitat and species conservation at an ecosystem level while allowing local land use authorities to better manage growth and development. Upon issuing an NCCP Permit, the California Department of Fish and Wildlife (CDFW) can authorize take of selected state listed species and other species of concern, subject to the terms of coverage under the NCCP (CDFW 2015). An HCP (Habitat Conservation Plan) is the federal counterpart to an NCCP; the U.S. Fish and Wildlife Service prepares HCPs and issues HCP permits. The terms and conditions under which an NCCP/HCP's protected areas are conserved establish the types and levels of public access that are permitted (Burger 2012). The types and levels of public access vary among the NCCP/HCP protected areas from no access to guided-only access to open access. The species protected by NCCPs/HCPs are typically called covered species.



bikers can appear more or less threatening to birds than a single pedestrian, Bernard et al.'s (2018) results underscore that the responses of wildlife to recreational activities vary among species, sites, types of recreation, and exposure over time to the activities.

*Songbirds.*—Davis et al.'s (2010) study of the effects of mountain biking on golden-cheeked warblers (*Dendroica chrysoparia*, warblers) with nests near biking trails in the Fort Hood Military Base in Killeen, Texas, USA, and the Balcones Canyonlands Preserve in Austin, Texas, found direct and indirect effects. The direct effects included warblers flushing >20 m in response to encounters with passing mountain bikers. Indirect effects included abandonment of nests <2 m from the biking trails and a reduction in the quality of nesting habitat due to biking-related fragmentation and alteration of habitats. In comparison to the control sites, it was likely that habitat fragmentation resulting from trails in the biking sites caused the increased predation of warbler nests by rat snakes (*Elaphe obsoleta*) and other edge-adapted predators. The authors speculated that the biking sites, which were able to maintain viable populations of warblers at the time of the study, may not continue to do so with additional recreational use, fragmentation, and alteration of the habitats.

*Forest birds.*—Bötsch et al. (2018) examined how breeding-bird communities changed with distance to trails in four broad-leaved and mature forests in Switzerland and France; the forests were similar in size, structure, and trails, but widely different in levels of recreation (mostly walkers). The authors found that: in the forests with high levels of recreation, the density and species richness of birds decreased by 12.6% and 4.0%, respectively, at points close to trails compared to points farther away; cavity, ground, and open-cup nesters had fewer territories and species close to trails compared to farther away; and, above-ground foragers and ground foragers showed a similar pattern. None of these effects on density, species richness, nesting guild, or foraging guild occurred in the forests with low levels of recreation. Both high- and low-sensitivity species (i.e., long versus short flight initiation distances) had fewer territories and fewer species close to versus far from trails in forests with high levels of recreation; however, in forests with low levels of recreation, highly sensitive species exhibited only a slight tendency for fewer territories close to trails. The authors inferred from their findings that (1) human presence in forests disturbs avian community composition and abundance along trails in recreational areas, (2) the overall effect of recreational trails themselves depends mainly on recreational intensity and only slightly on species characteristics, and (3) the observed effects on birds in forests where recreation has occurred for decades suggest that habituation to humans has not outweighed the effects.

*Raptors.*—In a study along the Boise River in Idaho, USA, examining flight initiation distances of bald eagles (*Haliaeetus leucocephalus*) in response to actual and simulated walkers, joggers, anglers, bikers, and vehicles, Spahr (1990) found that the highest frequency of eagle flushing was associated with walkers, followed by anglers, bikers, joggers, and vehicles. Eagles were most likely to flush when recreationists approached slowly or stopped to observe them, and were less alarmed when bikers or vehicles passed quickly at constant speeds. However, the longest flight initiation distance was in response to bikers, followed by vehicles, walkers, anglers, and joggers. Hennings' (2017) literature review provides the following about bald eagles: pedestrians within 275 m caused a 79% eagle response rate; eagles did not resume eating for four hours after disturbance by walkers; a suggested minimum 600-m buffer around breeding eagles, beyond which response frequency dropped below 30%; an apparent threshold of about 20 daily recreational events after which eagles were slow to resume feeding, and after 40 events, feeding was uncommon; sub-adults were

less tolerant of disturbance than adult eagles; and recreation-related long-term effects can include reductions in survival, particularly during winter and especially for juveniles.

With respect to the tolerance (through habitat imprinting, genetic inheritance, or habituation) of golden eagle (*Aquila chrysaetos*) for recreational disturbance, Pauli et al. (2017) used an individual-based model<sup>11</sup> to assess the effects of walkers and off-highway vehicles on golden eagle populations. The primary modeling results indicated that, while golden eagles can develop tolerance for recreational disturbance, tolerance for even moderate levels of disturbance may not develop within a population at a sufficient rate to offset the effects of increased recreation on breeding golden eagles, particularly because this is a long-lived species with low recruitment. Pauli et al. (2017) conclude that, taken together, the simulation results suggest that recreation-related disturbance has a substantial effect on golden eagle populations and that increased recreation activity will exacerbate such effects. Given the results and the fact that non-motorized recreation decreases the probability of egg-laying in golden eagles (Spaul and Heath 2016), the authors asserted that trail management and a reduction in recreation activity within eagle territories are necessary to maintain golden eagle populations in locations where levels of recreation are increasing.

*Shorebirds.*—In a controlled study conducted in Scotland of the behavioral responses of the ruddy turnstone (*Arenia interpres*) to an approaching human, Beale and Monaghan (2004) found that birds supplemented with food flushed sooner from the human and searched for predators more frequently than birds not supplemented with food. That is, birds responding most were actually the least likely to suffer any fitness consequences associated with the disturbance. This study demonstrates the possibility of misconstruing the reasons for and implications of observed responses among all wildlife species. Traditionally and intuitively, species that readily flee from or avoid human disturbance are considered to be the most in need of protection from disturbance. However, species with little suitable habitat available nearby cannot show marked avoidance of disturbance even if the costs of reduced survival or reproductive success are high, whereas species with many nearby alternative sites to move to are likely to move away from disturbance even if the costs of the disturbance are low (Gill et al. 2001). It should not be assumed that the most responsive animals are the most vulnerable (Beale and Monaghan 2004). Gill et al. (2001) asserted that the absence of an obvious behavioral response does not rule out a population-level effect. In the same vein, it may be that species occurring in protected areas that are remnant fragments within urban landscapes are forced to utilize all components of the fragments, irrespective of their land-use intensity and land cover. This may occur if animals have nowhere else to go, and may be an explanation for instances when the relative abundance of birds is greater in urban and suburban reserves than in exurban reserves (Markovchick-Nicholls et al. 2008).

## Mammals

*General responses within NCCP/HCP protected areas in southern California.*—In series of three studies about the responses of mammals to hikers and runners, bikers, horseback riders, dog walkers, and motorized vehicles, George and Crooks (2006), Patten et al. (2017), and Patten and Burger (2018) analyzed camera-trap data captured throughout areas protected under the 1995 County of Orange Central and Coastal NCCP/HCP (Orange County NCCP/HCP). All studies analyzed bobcat (*Lynx rufus*), coyote (*Canis latrans*), and mule

<sup>11</sup> Individual-based models are simulation statistical tools that use empirical data to examine effects, such as anthropogenic population-level effects, that are difficult or impossible to study in a field setting.

deer, and Patten et al.'s (2017) analysis also considered mountain lion (*Puma concolor*), gray fox (*Urocyon cinereoargenteus*), striped skunk (*Mephitis mephitis*), and northern raccoon (*Procyon lotor*). The authors found that: (1) mammal detections were negatively correlated with all types of recreationists; hikers and runners had the greatest negative association with wildlife, and equestrians had the least; (2) the overall trend is sharply negative: as human activity increased, mammalian activity decreased, regardless of species, type of human activity, or camera placement; (3) mammals were nearly four times as likely to be recorded on days with no human activity than on days with human activity at the same site; (4) detections of mammals decreased incrementally as the number of humans increased within a day, and fell to near zero probability at  $\geq 60$  humans per day; and (5) all seven species listed above exhibited short-term spatial displacement in response to events with more than 100 visitors.

Bobcats' negative associations were strongest with bikers, hikers, and domestic dogs. In areas of higher human activity, bobcat were detected less frequently along trails and appeared to show temporal displacement, becoming more nocturnal. Coyotes' overall activity was lower at the sites with the most recreation and was negatively associated with overall human, hiker, and biker visitations; and, a trend of temporal displacement in response to dogs was also evident. Generally, both bobcats and coyotes displayed a relatively wide range of activity levels at sites with low human use, but a lower and markedly restricted range of activity at those sites with the highest levels of recreation. Both coyotes and mule deer shifted their activities temporally over the long term. The mule deer's (a primary consumer) marked shift brought it into closer temporal alignment with its main predator (mountain lion) and the coyote's marked shift (secondary consumer) brought it into closer temporal alignment with a chief prey species (gray fox). These human-induced diel shifts involving animals in two trophic levels have important ramifications for predator-prey dynamics. Despite these studies' results, no evidence was found suggesting mammalian populations have declined in the Orange County NCCP/HCP protected areas between 2007 and 2016, even as human activity increased markedly across the study period. However, it is critical to consider this observation in light of: (1) the fact that, at least for the years 2007-2011, public access was controlled across most of the study area by permit-only entry, regular docent-led programs, and monthly self-guided wilderness access days—much higher levels of restrictions on public access than for most protected areas; (2) the authors' assertion that various mammalian species' avoidance behavior may yet drive mammalian populations downward upon further increase in human disturbance; and (3) the status of the Vail Colorado elk herd as recounted below—once a herd of 1,000 head diminished to 53 due to steadily increasing levels of recreation.

Overall, the results of the above three studies were similar to those of a study to assess recreationists' effects on sensitive wildlife species in 14 NCCP/HCP protected areas in San Diego County, for which Reed et al. (2019) used data from camera traps and a before-after-control-impact (BACI) experiment. Reed et al. found that bobcat, gray fox, mule deer, and northern raccoon were less active in areas with higher levels of human recreation. 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 for mule deer among the four studies suggest that mule deer may stop using some areas altogether if human recreation is too high. Reed et al. (2019) did not detect negative associations between human recreation and the habitat use or relative activity of the six following mammalian species of the 12 observed: coyote, striped skunk, ground squirrel, jackrabbit, brush rabbit

(*Sylvilagus bachmani*), and desert cottontail (*S. audubonii*). However, of special note are results from the protected area with the highest level of recreation (i.e., an average of 1,797 people per day) observed in the study, where the cameras captured only rabbits, and no other mid- to large-bodied wildlife species during 7.5 weeks of monitoring. Yet, this 2,449-ha protected area is considered a core biological area and regional wildlife corridor targeted for conservation (City of San Diego 2019). The BACI experiment conducted in another protected area showed a significant decrease in bobcat detection probability in a four-week period following a trail re-opening, suggesting that this species can modify its behavior (e.g., shift its activity patterns) rapidly after a change in human recreation. This is evidence that temporal closures have the potential to reduce disturbance during critical periods for some species. Although human recreation may not often extirpate mammalian species from urban habitat fragments, it can reduce habitat suitability and carrying capacity (Reed et al. 2019).

*Responses to human voice.*—Suraci et al. (2019) tested whether mammalian carnivores' responses to human voices alone can result in landscape-scale effects across wildlife communities, including cascading effects on the behavior of lower trophic level animals. The results of the study, which was conducted in the Santa Cruz Mountains of central California, USA, indicate that human voice alone does result in such effects. Where humans are absent or rare, large and medium-sized carnivores exhibit greater movement, activity, and foraging, while small mammals use less space and forage less. Where humans are present, the activity, foraging, and/or habitat use of large and medium-sized carnivores are suppressed, while small mammals increase their total space use and foraging intensity. The implications of these results are far-reaching, and include that, even in the absence of land development or habitat fragmentation, increased human presence can: (1) affect large carnivore movement, which could eventually limit carnivores' hunting and feeding behavior or force individuals to abandon high risk areas of their home range; (2) suppress activity of medium-sized carnivorous species; and (3) increase the abundance of small mammals that are prey to the large- and medium-sized predators, which could ultimately increase the abundance of small mammals in wildlife areas people visit (Suraci et al. 2019, citing other authors). Moreover, if the sublethal effects observed in the study in response to human voices alone are comparable to those effects (e.g., increased physiological stress, reduced reproductive success) that fear has been demonstrated to cause in predator-prey systems, they may amount to additional widespread but largely unmeasured effects of humans on wildlife populations (Suraci et al. 2019, citing other authors). Hennings (2017) provides additional insights about, and citations for studies on, the effects on wildlife from the human voice, concluding that conversational noise along trails can be very disturbing to wildlife.

*Ungulates.*— In a two-year study of elk (*Cervus elaphus*) in a herd near Vail in central Colorado, USA, Shively et al. (2005) found that elk reproductive success rebounded to pre-disturbance levels after the cessation of their exposure to back-country hikers during the calving season over the previous three years. Shively et al. concluded that, it seems prudent to protect elk during calving seasons, because, although the study provides evidence that elk reproduction can rebound from depressed levels when human disturbances are removed or reduced, there had been a linear decline in calf production in response to increasing levels of disturbance compared to controls without such disturbance, and it is not known if there is a threshold level of reproductive depression from which elk cannot recover. Recognizing that it is seldom easy to curb human activities that have become traditional, or to restore wildlife habitats once they have been developed, they recommended the continuation of

some closures imposed on parts of both the Vail and control elk herd study areas. However, a recent article in *The Guardian* reported that the number of elk in this same Vail herd dropped precipitously since the early 2010s with the steady increase in human recreation; once a herd of 1,000 head of elk, it had decreased to 53 at last count in February of 2019. The article explains that, for Bill Alldredge, one of the authors of the 2005 study, there is no other explanation than the increased levels of hiking, biking, and skiing in the area that supports this elk herd (Peterson 2019). This outcome adds to the already ample evidence that pregnant animals or those with young—especially mammals—are particularly sensitive to human disturbance (Hennings 2017).

In a study subjecting 13 captive female elk in the Starkey Experimental Forest and Range in Oregon, USA, to four types of recreational disturbances (all-terrain vehicles [ATV] riding, mountain biking, hiking, and horseback riding), Naylor et al. (2009) recorded the elk's resting, feeding, and travel times in response to the disturbances. The authors found travel time (a proxy for energy expense) increased in response to all four disturbances and was highest in mornings. The authors suggest that the elk's lesser response to each disturbance in afternoons was likely due to elk moving away from the disturbances in the mornings and avoiding them for the remainder of the day. Elk travel time was highest and feeding time lowest during ATV exposure, followed by exposure to mountain biking, hiking, and horseback riding. Resting decreased with exposure to mountain biking and hiking disturbance, and elk showed no evidence of habituation to mountain biking or hiking.

In a study of how bison (*Bison bison*), mule deer, and pronghorn (*Antilocapra americana*) responded to hikers and bikers on designated recreational trails at Antelope Island State Park in Great Salt Lake, Utah, USA, Taylor and Knight (2003) found the following: with respect to alert distance, flight initiation distance, and distance moved,<sup>12</sup> there was little difference in how each species responded to hikers versus mountain bikers (with an exception of mule deer flight distance), though each species exhibited its own degree of response in the three parameters tested; and all three species exhibited a 70% probability of flushing from on-trail recreationists within 100 m from designated trails. Trials were also conducted with only mule deer along a randomly chosen, off-trail route to assess the response of mule deer to hikers or bikers off designated trails. From these trials, the authors found that mule deer showed a 96% probability of flushing within 100 m of recreationists located off trails, and the probability of their flushing did not drop to 70% until perpendicular distance reached 390 m. There was little evidence of habituation to recreationists among the species at the time of the study. In fact, the pronghorn at the study site did not habituate to largely predictable recreational use over a three-year period following the opening of trails at the site, and used areas that were significantly farther from trails than they had prior to the start of recreational use.

*Carnivores.*—In a study of mammalian carnivores in 28 protected areas located in oak woodlands in northern California, USA, Reed and Merenlender (2008) found the following about carnivores' responses to recreationists. Generally, in paired comparisons of neighboring protected areas with and without recreation, the presence of dispersed, non-motorized recreation (hiking, biking, and horseback riding) led to a five-fold decline in the

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<sup>12</sup> Alert distance is the distance from a stimulus at which an animal initiates vigilance behavior; more specifically in this context, it is the distance between a recreationist and an animal when the animal first becomes visibly alert to the recreationist. Flight initiation distance is defined in footnote #9. Distance moved is the distance an animal travels from its initial position until it stops (Taylor and Knight 2003).

density of native carnivores and a substantial shift in community composition from native to nonnative species. Specifically, a higher mean number of native species was detected in protected areas that did not permit recreation. By contrast, in protected areas that permitted recreation, more nonnative species were detected, domestic dogs were detected more frequently, and densities of coyotes and bobcats were more than five times lower. The authors concluded that the key variable for moderately sized protected areas (50–2000 ha) near urban development seems to be whether or not the site is open to public access.

In a study within three protected areas in Arizona, USA, Baker and Leberg (2018) found the following about how 11 mammalian carnivore species respond to varying levels of hiking, horseback riding, and border patrol activity. The study sites with the highest levels of human activity had significantly lower carnivore diversity, higher occupancy of common species (coyote, gray fox, and bobcat), and lower occupancy of all other carnivorous species. Generally, rare carnivores (e.g., mountain lion and kit fox, *Vulpes macrotis*), badgers (*Taxidea taxus*), and gray foxes avoided trails, whereas common species (except gray fox) preferred trails. Overall, edges of protected areas appeared to negatively affect occupancy of nearly all the study's species, and the presence alone of roads and trails, and not necessarily how much they are used, has a significant negative effect on the occupancy of most carnivorous species. In general, coyotes and bobcats were the carnivores least sensitive to human disturbance, gray foxes had a moderate negative association with human disturbance variables, and smaller carnivores and mountain lions seemed to be exceptionally vulnerable to human disturbance. Furthermore, the higher the level of overall disturbance in a protected area, the more sensitive carnivores were to disturbance variables.

## Conclusions and Suggestions

With the expanding recreation-related disturbance to wildlife in protected areas, their dual role of conserving biological resources and providing nature-based recreational and educational opportunities for people presents a continual challenge to land managers and a continual threat to wildlife and the state's biodiversity, particularly sensitive species. The scientific literature provides clear evidence that recreation can disturb wildlife in several ways. Documented effects include detrimental changes to behavior, reproduction, growth, immune system function, levels of stress hormones, other physiological effects, and finally, the survival of individual animals and persistence of wildlife populations and communities. Having been observed on nearly every continent and in every major ecosystem on earth, recreation-related disturbance to wildlife is increasingly recognized as a threat to global biodiversity, and as having wide-ranging and, at times, profound implications for wildlife individuals, populations, and communities (Dertien et al. 2018). Yet, a prevalent assumption exists that non-consumptive recreation is compatible with wildlife conservation; sources that articulate this assumption in various ways include but are not limited to the Natural Community Conservation Plans/Habitat Conservation Plans (NCCPs/HCPs in the California Department of Fish and Wildlife's (CDFW) South Coast Region, Title 14 of the California Code of Regulations (§630(a)) about CDFW's ecological reserves, CDFW's 2016 State Wildlife Action Plan's Consumptive and Recreational Uses Companion Plan, Burger 2012, Larson et al. 2016, Dertien et al. 2018, and Reed et al. 2019. This assumption underlies the widespread acceptance of non-consumptive recreation in dual-role protected areas.

*Is the assumption of compatibility flawed?*—The assumption of compatibility rests on four expectations, which are often legal obligations (as with NCCPs/HCPs). First, recreation in protected areas is to occur only in ecologically sound locations. Second, only ecologically sound types, levels, and timing of recreation are acceptable. Third, monitoring is expected to regularly and reliably assess whether the types and levels of recreational activities in protected areas are disturbing the focal species to a degree that these activities should be curtailed or prohibited entirely. Fourth, changes in management are to occur promptly when monitoring determines them to be necessary (see footnote #5 for description of management). In short, the overarching expectation is that recreation would not hinder the achievement of the dual-role protected areas' primary conservation objective (i.e., perpetuation of viable populations of focal sensitive species). At least seven NCCPs/HCPs in the CDFW's South Coast Region explicitly deem recreation compatible or conditionally compatible; most articulate these expectations as conditions that recreational activities in protected areas must meet. Such activities are considered "conditionally compatible" with the protection of the covered species. However, the assumption of compatibility is flawed because: for example, designated trails and trail networks are often ecologically inappropriately planned, designed, or sited; and, even for authorized recreation, there is rarely adequate management to control the allowed types and levels of recreation such that they are compatible with conservation. While finding an appropriate balance between biodiversity conservation and recreation is complicated because recreation-related effects on wildlife vary among species and recreational activities (Larson et al. 2016), there are also societal factors at play that further complicate achieving an appropriate balance and compatibility.

*Factors allowing inappropriate planning/siting and inadequate management - a societal conundrum.*—The degree to which the above-listed expectations are met varies among NCCP/HCP permittees and other managers of dual-role protected areas, the primary limiting factors being fiscal constraints and each land manager's primary mission. As to the latter factor, for areas protected primarily or solely to conserve biological resources, a serious fundamental conflict with conservation arises when managers' primary mission is to provide recreational opportunities, and the protection of biological resources is a secondary or tertiary priority. As to fiscal constraints, land management budgets generally have not kept pace with the increasing levels of recreation in protected areas (CDFW 2015; Havlick et al. 2016). For example, the activities of the CDFW for resource assessment, conservation planning, and wildlife conservation at risk are "severely underfunded;" in 2005, maintenance, restoration, and management of CDFW's wildlife areas and ecological reserves were supported, on average, at the level of \$13 per acre (0.40 ha) and one staff person per 10,000 acres. Many lands were operated at \$1 per acre, with no dedicated staff (CDFW 2015—refer to Volume 1, Section 7.3). CDFW's fiscal shortfalls for managing its protected areas mirror the same among public agencies at the local, state, national, and international levels (CDFW 2015); these shortfalls result in continual grave shortages of management personnel and other resources.

California's State Wildlife Action Plan (CDFW 2015) and most of the literature about recreation-related ecological effects identify the economic, educational, and recreational/health benefits of protected areas. They also identify the benefits (e.g., economic) to protected areas from humans pursuing recreational activities. So, despite the documented recreation-related disturbance to wildlife, there seems to be an implicit assumption of a mutually beneficial relationship between protected areas and the humans who benefit from them. But,

the severe underfunding of management for protected areas renders mutual reciprocity in this relationship infeasible; the protected areas' wildlife are heavily on the losing side. This is particularly perplexing given the evidence that lack of adequate management negatively affects not only biological resources, but also societal benefits.

Regarding the human health benefits of protected areas, visible recreation-related damage to the terrain diminishes the level of benefit people enjoy while being in nature, as illustrated by a study examining the relationship between recreational impacts in protected areas and human mental/emotional states (Taff et al. 2019). The study's results demonstrate that, as visible recreation-related ecological impacts increased, sense of wellbeing and mental state decreased, especially in response to settings with unauthorized trails. Collectively, the results show that managing tourism in protected areas in a manner that reduces such impacts is essential to providing beneficial cultural ecosystem services related to human health and wellbeing (Taff et al. 2019). As Wolf et al. (2019) put it, the more attractive a site is, the more likely it is that it will be degraded, which in turn, may diminish the quality of the human experience, and thus, visitor satisfaction. To capitalize fully on the positive aspects of tourism (including recreation) for protected areas, the degradation of resources needs to be constrained to ecologically acceptable levels, and to levels beyond visitor perception (Davies and Newsome 2009; Wolf et al. 2019); otherwise, recreationists may think it unimportant to minimize their own impacts. Also diminishing the human experience are the closures to public access as a default reaction to lack of adequate management, and the liability resulting from injuries that can occur when people use unauthorized trails (Dertien et al. 2018).

There is a two-fold irony here: despite the prevalent emphasis on the societal benefits of protected areas and the purported reciprocal relationship between protected areas and humans, most agencies responsible for managing protected areas are chronically underfunded. And, promoting the pursuit of these societal benefits without protecting the dual-role protected areas' core function (biological conservation) from that pursuit actually undermines both the human experience and biological conservation. This is a societal conundrum that stems at least in part from a societal disconnection.

*The factor of a societal disconnection.*—A lack of public interest in and concern about protected areas figures into the societal conundrum. Public opposition to trail closures, caps on daily visitation, or reservation systems can be strong and could damage the support for conservation agencies and organizations (Reed et al. 2019), despite the ecological need for such measures for protected areas. A disconnection pervades our society with respect to recreation-related disturbance to wildlife (Marzano and Dandy 2012): 50% of 640 backcountry trail users surveyed in 2001 did not believe that recreation negatively affects wildlife, and recreationists generally held members of other user groups responsible for stress or negative effects on wildlife rather than holding members of their own recreational user group responsible (Taylor and Knight 2003). The results of a survey conducted in 2018 for the San Diego End Extinction (SDEE) initiative to elucidate what the San Diego public know, think, feel, and do in relation to species and habitat conservation, indicate that 71% of the 600 respondents are not knowledgeable about the problems San Diego's plants and wildlife face (Tinkler et al. 2019).<sup>13</sup> While the passage of California Proposition 68 in 2018 reflects the voters' broad support for clean water and access to open space, which were the main elements of the Proposition that promotional efforts emphasized, it is unclear how

<sup>13</sup> The respondents were San Diego County voters and were representative of the voter pool in terms of age, gender, ethnicity, and region, but voters tend to be less ethnically diverse and more educated than the San Diego County population overall (Tinkler et al. 2019).



much the biological conservation-related elements of the Proposition influenced voters.

Overall, it is probable that a large majority of the general public are unaware of or in denial about the disturbance to wildlife from non-consumptive recreation, much less the distinctions between areas protected primarily or solely for conservation and areas otherwise designated as open space (e.g., recreational fields, golf courses, small community parks). Information on these topics is not widely available, and what is in the literature, may not be reaching a broad audience even among conservation scientists and wildlife ecologists (Larson et al. 2016). What then can be done to address this unawareness as a step toward enabling dual-role protected areas to meet their conservation objectives despite the expanding recreational pressure?

*Suggested plan of action.*—To enable dual-role protected areas to meet their conservation objectives despite the expanding recreational pressure, the optimal approach is to: ensure that all recreational areas (e.g., trails and trail networks) are planned, designed, and sited using ecologically sound criteria; and, to continually employ sufficient proactive and adaptive management to prevent or at least minimize recreation-related disturbance to wildlife; such management would curtail the need for regular enforcement. This approach also has the potential to yield general public support for management, particularly if information provided about management challenges includes data and supporting graphics, specifically about fragmentation, to enhance the public's understanding of the challenges of poorly designed trail systems and the creation and use of unauthorized trails (Leung et al. 2011; Taff et al. 2019; Wolf et al. 2019). But this approach requires perpetual personnel and funding explicitly for management, which in turn points to the urgent need for public advocacy to secure fiscal support for management resources (i.e., fiscal support that is sustainable, perpetual, and at levels commensurate with the recreational pressure; footnote #5). How can this be achieved?

How people perceive their and others' recreation-related effects on wildlife may influence their general perspectives on such effects (Marzano and Dandy 2012). Shifting this perception-perspective nexus over time toward a common value of respecting wildlife may eventually mend some of the aforementioned societal disconnection. A shift in perspectives on the purpose of protected areas is also needed to one of understanding and acknowledging that their core function is conservation (Davies and Newsome 2009; Patten et al. 2017). The only chance there is of influencing people's perceptions is making the pertinent scientific information readily available. So, it is essential to implement a concerted campaign to disseminate science-based information about recreation-related disturbance to wildlife. Such a campaign needs to be well orchestrated, widespread, long-term, continual, and multimedia; this includes social media per Greer et al.'s (2017) conclusions about its efficacy in this context. In addition to the general public/voters (including recreationists), the following parties would be both the audience and the distributors within each of their fields and beyond: the media, environmental organizations, elected officials, policy and land-use decision makers, land management agencies and organizations, outdoor recreation merchants and associations, educational institutions, and researchers. The coverage would be framed as stories aimed to evoke appreciation for the diversity of sensitive species and the many ways they respond to our presence, and provide opportunities for what people can do to lessen the recreation-related disturbance to wildlife, which will benefit not only wildlife and other biological resources in the protected areas, but also the human experience there.

While the objectives of the campaign would be to influence people's perspectives in favor of wildlife and to modify recreational behaviors, policy, planning, and decision-

making accordingly, the final goal would be to cultivate support for and harness the power of advocacy to gain the political will and action needed to secure perpetual fiscal support for management resources. Implementing such a campaign would not be easy nor fast and would take diligent oversight, as suggested by William Craven, the chief consultant for nearly 20 years of California's Senate Natural Resources and Water Committee. In an interview with the California Native Plant Society, he stated, "the best way to achieve your policy objectives is to make sure your policy objectives are funded. For example, small but important programs for the [California Department of Fish and Wildlife] are literally budget dust in the California budget, but unless someone is there to pay attention and connect the dots between the budget and the state laws, we don't get a complete resolution...[P]ositive changes in state law that everyone works so hard to accomplish are really much more effective when someone monitors the budget process to make sure those changes get as much funding as possible" (CNPS 2020). But, it seems that the choices are either to never reverse or at least halt the downward trajectory of wildlife in protected areas experiencing damaging levels and types of recreation or to ambitiously implement such a campaign toward a societal course change (Waterman 2019 for the term "course change").

Several of the results of the survey conducted for the SDEE initiative hint at a potential to mobilize a critical mass of people who learn about the recreation-related disturbance to wildlife and the associated urgent need for resources to address it, and assist in information dissemination. While the survey conducted for the SDEE initiative revealed a knowledge deficit among the respondents regarding problems plants and wildlife face, its results also indicate that, over a 12-month period, 74% of respondents voted in favor of laws to protect the environment, 31% volunteered to improve the environment, and 21% donated money to protect San Diego County's environment; in addition, approximately 70% were willing to pay additional local taxes to protect the environment, and a majority of the respondents were willing to pay up to \$50 per year (Tinkler et al. 2019).

One avenue available for advocacy to secure perpetual fiscal support specifically for management of protected areas is assessing recreational fees and taxes. With respect specifically to the management of CDFW-owned protected areas, CDFW's 2005 and 2015 State Wildlife Action Plans recommended implementation of recreational fees and taxes beyond fishing and hunting licenses that would allow non-consumptive recreationists to support wildlife conservation and management of the resources they use and enjoy (CDFW 2015, 2016). To generate funds for the management of all protected areas, a long-successful model could be employed: since the 1930s, hunters have been paying federal excise taxes on the sales of sport hunting and shooting equipment to generate funding for habitat conservation (CDFW 2015). Eighty years later, these taxes plus sales of angling equipment had generated more than \$10 billion towards conservation (CDFW 2015). Thus, hunters and anglers have been the primary funding sources for conservation efforts in California and North America (CDFW 2015). Considering the disturbance to wildlife from non-consumptive recreationists, it is past time for them also to pay their way for the use of protected areas through paying taxes on equipment for hiking, biking, riding, etc. to support management of these activities. A secondary benefit of such fees and taxes is that they may establish a direct connection for recreationists between their use of protected areas and the costs of protecting the protected areas, and thereby possibly diminish their disconnection from their disturbance to wildlife.

Other avenues for advocacy to secure fiscal support for management of protected areas include bond measures and voluntary contribution funds (VCF), though neither would necessarily provide a reliably perpetual source of funding. VCFs are sponsored by legislators

to be enacted by the legislature; a VCF in this context would be explicitly and solely for the management of the protected areas in California, including CDFW's lands (with protected areas and management defined as described in footnotes #1 and #5, respectively). The funds must be administered such that they are made available timely. This would be similar to the VCF for California's Rare and Endangered Species Preservation Voluntary Tax Contribution Program which has funded work benefiting California's native at-risk plants, wildlife, and fish since 1983 (CDFW 2019) and now raises around \$500,000 annually (FTB 2019).

Mainstream online and print media carried several articles in 2018 and 2019 about the overcrowding at and underfunding for the national parks (e.g., Simmonds et al. 2018; Waterman 2019; Wilson 2019); coverage such as this provides a good foundation of information. Articles like Yong's (2019) about the effects of the human voice alone on wildlife and Peterson's (2019) about the effects of hiking on elk represent steps in the right direction toward mainstream media honing in on specific impacts on wildlife from recreationists in protected areas. Coverage on species local to where people live is important and may make a stronger and more lasting impression with greater potential for shifting the perception-perspective nexus than species or settings remote from consumers of the media. Organizations like San Diego Zoo Global, which spearheaded the SDEE initiative (Tinkler et al. 2019), could significantly assist the campaign by engaging their media engines on behalf of local wildlife threatened by recreation.

*A societal quid pro quo for protected areas?*—At some point, the exploitation of protected areas resulting from recreation-related disturbance to wildlife, without commensurate reciprocity with care for the protected areas, may outweigh the benefits of public access to protected areas (Bennett et al. 2013). Many protected areas have already reached this point. Without adequate resources to combat the challenge of the obligation to conserve wildlife exposed to ecologically damaging levels and types of recreation, including unauthorized activities, the challenge will persist indefinitely at great risk of jeopardizing the protected areas' ability to meet their conservation objectives.

Regarding the pressure local, state, and federal government agencies have undergone for decades to acquire additional open space for recreation and to expand public access in existing protected areas (Wells 2000 in Reed and Merenlender 2008), elected officials and land-use decision makers need to address the demands, but not at the expense of biological conservation in protected areas. Some of the protected areas (e.g., the NCCP/HCP reserves) represent long-negotiated compromises for the sensitive species they are intended to protect in perpetuity. For some protected areas, no ecologically sound further compromise (e.g., expansion of public access) is possible; while recreation may be considered conditionally compatible in such protected areas, if open to public access at all, the extant levels of recreation may strain their ability to meet their conservation objectives. Protected areas that represent the final compromise for the species they support are particularly vulnerable to their wildlife values being compromised due to inadequate management (CDFW 2015). Ultimately, for wildlife that avoids human activity, it is unlikely that dual-role protected areas are entirely sufficient or justifiable for meeting conservation objectives; limiting or prohibiting recreation in strategic circumstances and locations within protected areas is necessary to achieve conservation objectives (Reed and Merenlender 2008; Bötsch et al. 2018; Dertien et al. 2018; Reed et al. 2019). Of course, this presumes sufficient management to maintain whatever recreational limits are set.

In summary, in the interest of wildlife in California and, more broadly, conservation within protected areas everywhere, the necessary actions with respect to non-consumptive

recreation are to: (1) widely and continually disseminate science-based information about the recreation-related disturbance to wildlife; (2) apply the science to all planning for, policy- and decision-making about, and management of, recreation in dual-role protected areas; and (3) secure perpetual fiscal support for management of recreation in dual-role protected areas commensurate with the recreational pressure.

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## **Increased hiking and mountain biking are associated with declines in urban mammal activity**

COURTNEY L. LARSON<sup>1,2\*</sup>, SARAH E. REED<sup>1,3</sup>, AND KEVIN R. CROOKS<sup>1</sup>

<sup>1</sup> *Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO USA*

<sup>2</sup> *Current address: The Nature Conservancy, Wyoming Field Office, Lander, WY USA*

<sup>3</sup> *Robert and Patricia Switzer Foundation, Belfast, ME USA*

*\*Corresponding Author: courtney.larson@tnc.org*

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Outdoor recreation can have negative consequences for many wildlife species (Larson et al. 2019, 2016; Monz et al. 2013; Sato et al. 2013). Increasingly, parks and preserves are embedded in a landscape of urban and suburban development (Radeloff et al. 2010), intensifying the exposure of remaining wildlife populations to human activity (Larson et al. 2018). In California, several research groups have studied wildlife responses to recreation in parks and preserves within densely populated coastal cities. Some of the resulting studies have documented negative effects, including declines in native mammal occupancy and detection rates (Patten and Burger 2018; Reed and Merenlender 2008) and reduced daytime activity (George and Crooks 2006), while others have found limited effects of recreation on wildlife occupancy and detection rates (Markovchick-Nicholls et al. 2008; Reilly et al. 2017). Managers need context-specific understanding of the nature and severity of recreation effects on wildlife to sustainably manage recreational use in protected areas, the vast majority of which are open to the public (Leung et al. 2018; UNEP-WCMC and IUCN 2019).

Experimental tests of recreation effects on wildlife can provide valuable insight into species' responses to human activity by minimizing variation in other factors that affect wildlife, such as residential development and vegetation composition. However, fewer than one-third of studies of recreation effects on wildlife include an experimental component (Larson et al. 2016), and a large proportion of experimental treatments exclusively measure immediate reactions of wildlife to an approaching human, often using flight initiation distance (e.g., Ikuta and Blumstein 2003; Jorgensen et al. 2016; Keeley and Bechard 2011). These immediate responses cause increased energy expenditure and can trigger trade-offs between

foraging and flight behaviors (Duchesne et al. 2000), but it is less clear how they may translate into longer-term habitat degradation due to the regular presence of recreationists. It can be logistically difficult to experimentally alter the level of recreation on a trail segment or within a defined area, but when successfully implemented such studies have documented increased presence of nest predators (Gutzwiller et al. 2002) and reduced numbers of bird territories and bird species richness (Bötsch et al. 2017).

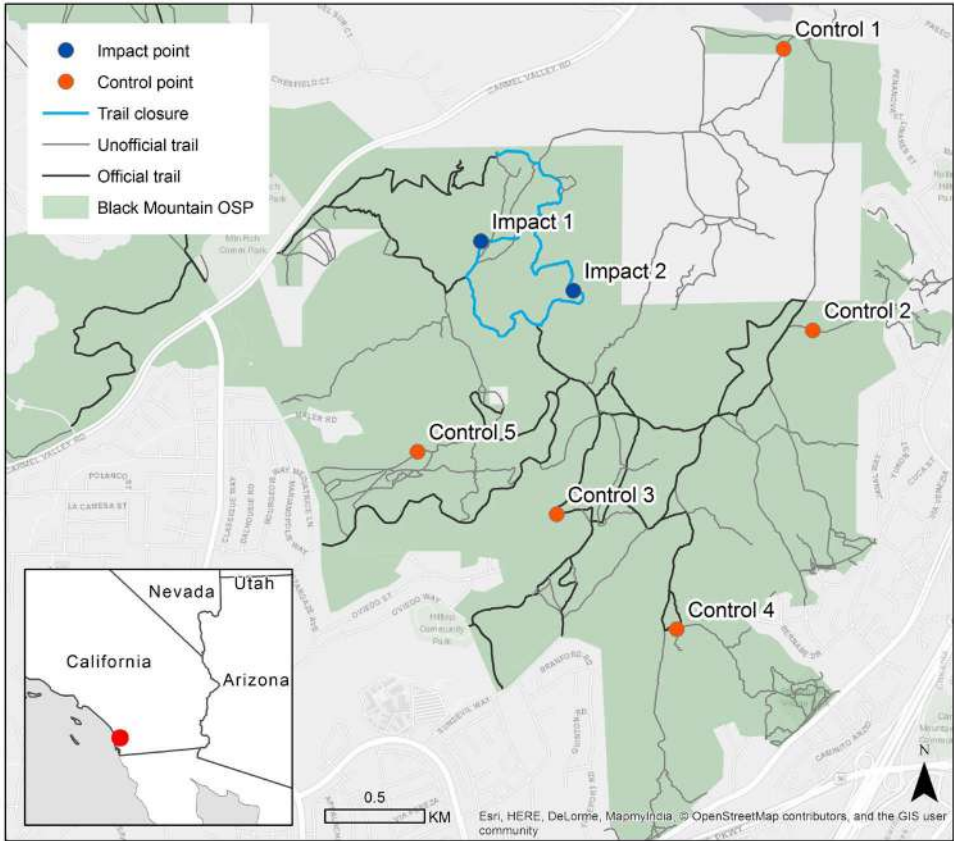
Conservation of mammals in densely populated and fragmented habitats such as southern California requires an understanding of the suitability of remaining habitat patches (Crooks 2002; Ordeñana et al. 2010), many of which receive high levels of recreational use (Larson et al. 2018). In this study, we assessed whether increased recreation rates were associated with reduced habitat suitability for native mammals. We conducted an opportunistic, quasi-experimental study of recreation effects on mammals using a before-after-control-impact (BACI) design, taking advantage of the closure and re-opening of an existing recreational trail in an open space park in San Diego, California. We expected that at impact locations (sampling points on the trail that was closed and re-opened), hiking and mountain biking would increase and wildlife activity would decline after the trail re-opened, while human and wildlife activity would remain similar at control locations (sampling points on trails consistently open throughout the study) within the same reserve.

The study was conducted in Black Mountain Open Space Park (32.984, -117.117) in San Diego, California, USA, which is owned and managed by the City of San Diego. The park is 951 ha, comprised primarily of coastal sage scrub and chaparral vegetation communities with some riparian and native and non-native grassland habitats. Dense suburban communities surround the park, and it contains approximately 32 kilometers of multi-use trails visited primarily by hikers and mountain bikers. The park also permits leashed dogs on the trails.

We established a total of seven sampling points on official and unofficial trails within the park in January 2017. Two points were located along the Miner's Ridge loop trail ("impact points", Figure 1), which was closed to public access from January 2017 until April 2018 for testing and remediation of elevated levels of arsenic detected in the soil. Five points were located along nearby trails not affected by the closure ("control points"; Figure 1). Point locations were selected as part of a larger project using a spatially balanced random design using the RRQR algorithm on rasterized trail network data (Theobald et al. 2007).

To monitor human and mammal activity, we installed one motion-triggered camera (Bushnell TrophyCam HD Aggressor) at each sampling point, housed in metal security boxes and affixed to metal poles pounded into the soil facing recreational trails. We did not bait the cameras to avoid influencing animal activity (Wearn and Glover-Kapfer 2019). Cameras were programmed to take two photos per trigger with a five second delay between triggers. We began monitoring human and mammal activity at the impact points in late October 2017, leaving cameras running continuously until after the trail re-opened in April 2018. At the control points, we collected data between November 2017 and February 2018. After the trail re-opened, cameras operated at all seven sampling points for at least four weeks, ending in June 2018 (Table 1).

The seven cameras captured over 80,000 photos during the study period. Many of these were "false triggers" caused by rapidly growing vegetation, high temperatures, and wind, mostly in the mid-morning to late afternoon. Therefore, we randomly subsampled 20% of photos between 11 am and 5 pm at all sampling points to reduce time spent sorting



**Figure 1.** Location and sampling design of the before-after-control-impact (BACI) study conducted in Black Mountain Open Space Park in San Diego, CA, USA.

**Table 1.** Dates of camera data collection before and after the trail re-opened at impact and control sampling points at Black Mountain Open Space Park. Cameras were not installed or did not operate correctly on all days between the first and last sampling day; the “total days” columns report the number of days on which cameras were operational.

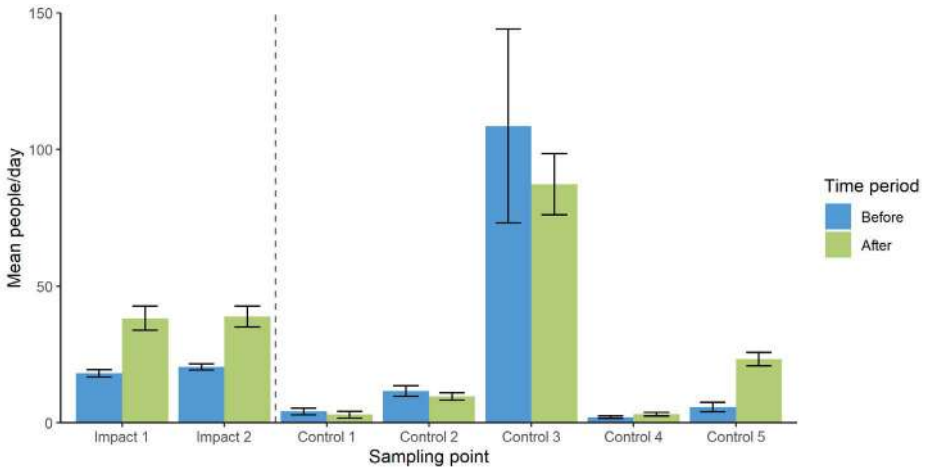
Point	Sampling effort before trail re-opened			Sampling effort after trail re-opened		
	First day	Last day	Total days	First day	Last day	Total days
Impact 1	1 Nov 2017	17 Apr 2018	134	19 Apr 2018	31 May 2018	43
Impact 2	1 Nov 2017	17 Apr 2018	168	19 Apr 2018	28 Apr 2018	27
Control 1	12 Dec 2017	1 Feb 2018	26	18 May 2018	30 May 2018	13
Control 2	12 Dec 2017	1 Feb 2018	26	4 May 2018	31 May 2018	28
Control 3	18 Nov 2017	13 Dec 2017	5	4 May 2018	30 May 2018	22
Control 4	18 Nov 2017	22 Dec 2017	26	4 May 2018	30 May 2018	28
Control 5	19 Nov 2017	22 Dec 2017	21	4 May 2018	31 May 2018	29

photos. Photos were organized in the Colorado Parks & Wildlife Photo Warehouse (Ivan and Newkirk 2016). Humans appearing in photos were categorized by activity (pedestrian, cyclist, equestrian, or vehicle) and animals were identified to species, except for brush rabbit (*Sylvilagus bachmani*) and desert cottontail (*S. audubonii*), which are difficult to distinguish in photos and were both labeled “rabbit.”

To assess changes in human activity before and after the trail re-opened, we compared mean people per day at impact and control points using a non-parametric Wilcoxon-Mann-Whitney test since the data are counts. To assess changes in mammal habitat use before and after the trail re-opened, we used single-species occupancy models for each mammal species with sufficient detections using the R package *unmarked* (Fiske and Chandler 2011). Detection data were pooled into 5-day sampling occasions, resulting in ten survey occasions with five before and five after the trail re-opening. We did not include habitat covariates because minimal changes in habitat occurred between the sampling periods and because our primary goal was to investigate the interaction of treatment (control or impact sampling point) and time period (before or after the trail re-opened). Therefore, treatment and time period were the only variables included in the models, and we included the interaction (treatment\*period) to test whether species showed a response to the trail re-opening. When a species was predicted to occur at all or nearly all sampling points, we assessed changes in detection probability rather than occupancy as a measure of relative activity or frequency of habitat use (Lewis et al. 2015; Wang et al. 2015).

Across all sampling points and time periods, there were an average ( $\pm 1$  SD) of  $12.2 \pm 21.7$  hikers,  $7.2 \pm 10.0$  cyclists,  $1.7 \pm 3.2$  dogs, and  $0.01 \pm 0.2$  horseback riders per day at each sampling point, as well as infrequent motorized vehicles (park staff or utility personnel) at one sampling point where the trail was drivable. These recreation rates are relatively low compared to other parks and preserves in the region (Larson et al. 2018). People did not cease using the trail while it was closed, with the two impact points averaging  $18.0 \pm 15.8$  and  $20.4 \pm 14.9$  people per day during the closure (Figure 2). However, human activity approximately doubled at the impact points after the trail re-opened, averaging  $38.2 \pm 28.9$  and  $38.9 \pm 19.6$  per day (time period differences:  $P < 0.001$ ). At the control points, human activity was similar between time periods (all  $P > 0.33$ ) except for Control 5, which averaged  $5.7 \pm 8.1$  people per day before and  $23.2 \pm 13.0$  after the trail re-opened ( $P < 0.001$ ). Control 5, located on an unofficial trail, is not part of the most obvious loop routes that could be made using the closed trail, but it could be connected with a longer loop route using unofficial trails, and therefore may have experienced depressed visitation rates during the closure period. Therefore, we ran additional occupancy models in which Control 5 was considered an impact point to ensure our results were robust to this possibility.

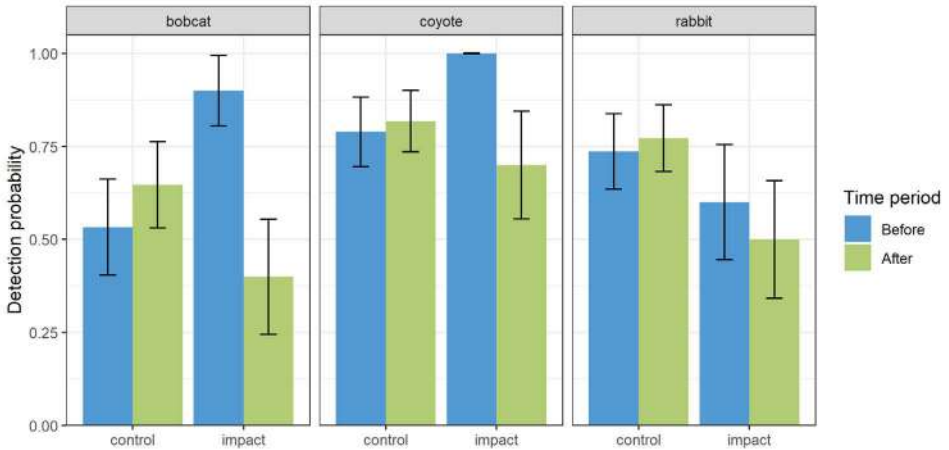
Mammal species we detected included rabbits (*Sylvilagus spp.*, total photos  $n = 537$ ), coyotes (*Canis latrans*,  $n = 409$ ), bobcats (*Lynx rufus*,  $n = 135$ ), California ground squirrels (*Otospermophilus beecheyi*,  $n = 22$ ), black-tailed jackrabbits (*Lepus californicus*,  $n = 4$ ), raccoons (*Procyon lotor*,  $n = 2$ ), and mule deer (*Odocoileus hemionus*,  $n = 1$ ). However, only the bobcat, coyote, and rabbit were detected frequently enough for analysis. Bobcats were detected at six out of seven sampling points, and coyotes and rabbits were detected at all seven points; accordingly, we used detection probability rather than occupancy as our primary variable measuring changes in frequency of habitat use for all three species. At sampling points where they were detected, each species was detected at least once before and after the trail re-opening.



**Figure 2.** Human activity (mean people per day) before and after the Miners Ridge Loop trail re-opened at impact and control sampling points at Black Mountain Open Space Park. Error bars show one standard error. Differences between time periods were significant ( $p < 0.05$  using a  $t$ -test) at Impact 1, Impact 2, and Control 5. The vertical dotted line divides the impact points (left) from the control points (right).

Occupancy models showed that detection probability was reduced at impact points after the trail re-opened for bobcats and coyotes, while remaining approximately the same at the control points (Figure 3). The effect was particularly strong for bobcats, with detection probability dropping from  $0.90 \pm 0.09$  to  $0.40 \pm 0.15$  at impact points after the trail re-opened while detection probability at control points increased slightly from  $0.53 \pm 0.13$  to  $0.65 \pm 0.12$ . The interaction of treatment\*period for bobcats was significant ( $z = 2.15$ ,  $P = 0.03$ ). Coyotes were detected at impact points during nearly every occasion before the trail re-opened (detection probability of  $1.00 \pm 0.001$ ) but afterwards detection probability dropped to  $0.70 \pm 0.14$ , while detection probability increased slightly at control points from  $0.79 \pm 0.09$  to  $0.82 \pm 0.08$ . However, the interaction term was not significant for coyotes ( $z = 0.14$ ,  $P = 0.89$ ). Rabbit detection probability did not differ significantly in relation to time period or treatment (interaction term  $z = 0.52$ ,  $P = 0.61$ ). Results did not change for bobcats or rabbits when Control 5 was considered an impact rather than a control point, but for coyotes patterns became less clear, with detection probability dropping more at control than impact points after the trail re-opened.

The number of sampling points was small due to the opportunistic nature of our study, limiting our ability to detect an effect of altered recreation rates on wildlife activity. Therefore, the fact that we still observed reduced activity rates by bobcats and, to a lesser extent, coyotes is particularly notable. Our findings echo those of previous studies in the region, which have found that these species and other mammals avoid human presence on short time scales (same-day occurrence; Patten and Burger 2018), and restrict their activity



**Figure 3.** Predicted detection probabilities from single-species occupancy models for bobcats, coyotes, and rabbits before and after the Miners Ridge Loop trail re-opened at impact and control sampling points at Black Mountain Open Space Park. Error bars show one standard error. The interaction term for treatment\*period was significant ( $P < 0.05$ ) for bobcats.

in high human-use areas (George and Crooks 2006). We observed greater responsiveness in bobcats than in coyotes. While both carnivore species have shown sensitivity to recreation in previous studies (Patten and Burger, 2018; Reed and Merenlender 2008), coyotes can be relatively tolerant of human disturbance due to their adaptable behavior and omnivorous diet (Riley et al. 2003; Ordeñana et al. 2010). We did not observe changes in rabbit activity rates in connection with increased human activity, or by extension, reduced predator activity. Their smaller home ranges compared to bobcats and coyotes may mean that they are less able to shift their within-home range habitat use in response to short-term changes in human and predator activity.

Previous studies have also found that these species may shift their diel activity patterns to be more nocturnal in areas with higher human use (George and Crooks 2006; Reilly et al. 2017; Wang et al. 2015; Nickel et al. 2020). While shifts in diel activity patterns may have occurred in our system, overall activity levels were lower after the trail was re-opened, indicating that any temporal shift did not completely mitigate effects of human presence. However, despite changes in activity levels (as measured by detection probability), we did not observe changes in the occupancy status of the sampling points, suggesting that while the habitat may have been somewhat degraded, it was not completely unsuitable after the trail re-opened. Given the relatively small size of the park and its highly developed surroundings, reduced use of impact points by bobcats and coyotes likely indicates a partial shift in habitat use to other areas of the park. Bobcats slightly increased their use of the control points after the trail re-opened, perhaps suggesting such a shift, though this difference was negligible for coyotes.

Future experimental manipulations at larger spatial and temporal scales could help assess the consistency of our findings, increase the precision of estimated detection probability parameters, and assess responses of additional wildlife species. The opportunistic nature of our study design resulted in spatial separation of the impact and control points,

which may have limited their ability to serve as true replicates due to spatial autocorrelation (Legendre 1993). A true experimental design with randomly assigned treatment and control locations would provide stronger evidence of recreation effects, such as the study by Bötsch et al. (2017) which documented reductions in bird territory establishment in response to low levels of recreation compared to areas with no recreation. Coordination with volunteer groups and docent-led programs or using recorded human voices (e.g., Suraci et al. 2019; Ware et al. 2015) could make it more feasible to experimentally apply treatments that simulate higher levels of recreation.

Though the level of human activity approximately doubled after the trail was re-opened, we speculate that the difference may not have been obvious to recreationists. Forty people per day, approximately the average level of use after the trail re-opened, is still low compared to many other San Diego-area parks and preserves (Reed et al. 2019). However, this difference appears to have been perceptible and meaningful to wildlife, and perhaps crossed a critical threshold of disturbance causing reduced rates of use of the trail. Accordingly, habitat degradation near trails due to human disturbance is likely common across parks and preserves across the region.

Our findings highlight that wildlife can respond rapidly to changes in the levels of human disturbance, even when they have experienced similar levels of disturbance previously. Data collection for the ‘after’ period started immediately after the trail was re-opened and continued for four weeks. The observed reduction in detection probabilities suggests that bobcats, and to a lesser degree coyotes, may respond to changes in the relative intensity of human activity by rapidly altering their fine-scale habitat selection. Rapid avoidance responses to recreation have been previously documented for mountain caribou (Lesmerises et al. 2018) and bottlenose dolphins (Lusseau 2004), but it is not clear how short-term behavioral avoidance may translate to fitness or population impacts (Bejder et al. 2006). Higher recreation intensity was presumably not novel to these individuals since the trail had been open to recreation for many years prior to our study, which suggests that the animals were not fully tolerant of prior levels of human disturbance. It is therefore possible that for these species, habitat degradation from recreation could be relatively quickly reversed if human activity was limited to lower levels, or spatially or temporally constrained. Land and wildlife managers often use seasonal closures to protect wildlife during periods of heightened sensitivity such as the breeding period (Burger and Niles 2013; Coleman et al. 2013; Richardson and Miller 1997), but the efficacy of these closures is rarely tested. The rapid response we observed suggests that targeted temporal closures could be a promising approach for reducing impacts of recreation.

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**Author contributions:**

Conceived and designed the study: CLL, SER, KRC

Collected the data: CLL

Performed the analysis of the data: CLL

Authored the manuscript: CLL

Provided critical revision of the manuscript: CLL, SER, KRC

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# **An assessment of non-consumptive recreation effects on wildlife: current and future research, management implications, and next steps**

JOHN BAAS<sup>1\*</sup>, KARI DUPLER<sup>2</sup>, AUDREY SMITH<sup>3</sup>, AND RACHAEL CARNES<sup>4</sup>

<sup>1</sup> *WRA, Inc., 4225 Hollis Street, Emeryville, CA 94608, USA*

<sup>2</sup> *WRA, Inc., 2169-G Francisco Boulevard E, San Rafael, CA 94901, USA*

<sup>3</sup> *PSE Healthy Energy, 1440 Broadway, Suite 750, Oakland, CA 94612, USA*

<sup>4</sup> *Environmental Science Associates, 180 Grand Avenue, Oakland, CA 94612, USA*

*\*Corresponding Author: baas@wra-ca.com*

Most research on the effects of non-consumptive recreation on wildlife to date has focused on birds and mammals. This research typically focuses on behavioral responses of individuals despite practical limitations in extrapolating ecological outcomes from individual behavior. Data gaps therefore present difficulties in integrating wildlife-protective policies into public access management. These gaps are exacerbated by a lack of wildlife studies that include data on public use patterns of open space areas. In a survey of park and open space managers in the San Francisco Bay Area, few of the entities surveyed restricted recreational access permanently or seasonally to address biological constraints; yet most indicated the presence of sensitive plant or animal species on their lands or stated conservation as one of their organization's purposes. To better bridge the gap between research and management practice, more research is needed on species beyond birds and mammals. This research should extend beyond noting behavioral response and should integrate investigation of outdoor recreation use patterns.

**Key words:** California, non-consumptive recreation, open space, parks, public access management, San Francisco Bay Area, wildlife

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Throughout the state of California, there exists a large diversity of designated open space and protected areas that allow public access and outdoor recreation. Based on data from the Survey of Public Opinions and Attitudes on Outdoor Recreation in California, the average number of days of outdoor recreation participation among adult Californians

is 96 days per year (California State Parks 2012). Based on California's population of approximately 27.4 million adults in 2008, California State Parks estimated approximately 2.6 billion days of outdoor recreation by adults during that year; that figure would be higher based on current population estimates. Within regional, state, or national parks, outdoor recreation participation (i.e., adults and children) totaled an estimated 478 million days, and for non-park natural and undeveloped areas there were an estimated 368 million annual days of outdoor recreation participation (California State Parks 2011).

A large portion of outdoor recreation activity consists of frequent use in the same areas by the same visitors. Much of it is relatively close to visitors' homes, and with California's warm, Mediterranean climate, outdoor recreation use often occurs near dawn and dusk, the times of day when multiple wildlife species are most active. Many areas where outdoor recreation occurs also provide occupied or potentially suitable habitat for special status wildlife species. California includes a variety of habitats that are occupied or potentially occupied by 181 state or federally listed wildlife species (CDFW 2019).

Non-consumptive forms of outdoor recreation (defined as those activities that do not include fishing and hunting) can impact wildlife species and their habitats in a variety of ways. There may be loss of individuals along trail corridors through incidental recreational use, such as crushing burrows or destroying nests. Non-consumptive recreation may also affect habitat. For example, recreation facility development can remove habitat, and recreational use of facilities can result in water quality degradation, soil erosion, and ground cover loss (USDA 2008). Presence of humans may cause displacement or change in behavior of wildlife, both temporary and permanent, through proximity to habitat, habitual use of an area (e.g., trails), or through direct harassment (Trulio et al. 2013; Shannon et al. 2014). There may also be effects on wildlife behavior from nighttime outdoor recreation activity, including light and sound pollution, or other disturbances associated with these recreational activities. Littering can have both direct and indirect effects (Boorman 2002), and bringing pets to open space and other types of protected areas may also cause direct and indirect impacts to wildlife species (Reed and Merelender 2008; Reilly et al. 2017).

However, despite more than 40 years of research on this topic, significant information gaps exist. The purpose of this article is to: 1) summarize what is known about effects on non-consumptive recreation on wildlife, 2) summarize current management practices used by park and recreation agencies in the San Francisco Bay Area to manage public access to protect wildlife, and 3) suggest additional research that will help fish and wildlife managers as well as park and open space managers more effectively manage and respond to potential impacts of non-consumptive outdoor recreation on wildlife species and their habitats.

## CURRENT STATE OF THE KNOWLEDGE

### Overall state of the knowledge

To preliminarily identify potential data gaps and long-term trends in the literature, we searched Google Scholar for articles containing the keywords "non-consumptive recreation" and "wildlife" at ten-year increments from 1980 to 2019. We subsequently performed the same query substituting "plants" for "wildlife." We identified 515 results containing the keywords "non-consumptive recreation" and "wildlife" between 1980 and 2019. Of these, 26 (5%) were published in the 1980s, 82 (16%) in the 1990s, 170 (33%) in the 2000s, and

237 (46%) in the 2010s. The same search with “plants” substituted for “wildlife” yielded 298 results between 1980 and 2019—15 (5%) in the 1980s, 44 (15%) in the 1990s, 105 (35%) in the 2000s, and 134 (45%) in the 2010s.

It is clear that the number of articles related to non-consumptive recreation and plant and wildlife management has increased over time, and that wildlife is consistently more studied than plants. More granular trends in the literature are less immediately apparent. We therefore identified several comprehensive literature reviews from the last 40 years to better understand which topics in plant and wildlife management are most often studied. In particular, we sought out reviews that would elucidate long-term trends in which types of recreational activities are the most studied, whether response variables are typically quantified at the individual or population level, which taxa are the most studied, and other trends that may inform the scope of future research. Due to the higher volume of studies available on wildlife than plants, we focused our efforts on wildlife-centered articles.

Boyle and Samson (1985) conducted a comprehensive review of the state of knowledge in which they identified trends in studies containing original data on terrestrial vertebrates in North America ( $n = 166$ ). These articles most often studied birds (103, 62%), followed by mammals (70, 42%), with few studies of herpetofauna (7, 4%). Boyle and Samson reported negative effects for most activities and taxa, postulating potential mechanisms such as direct disturbance and indirect effects such as habitat degradation, noting that the latter may result in simpler vegetation profiles and overall loss of habitat diversity. Positive effects on overall biodiversity were reported in a few studies, but these positive effects typically corresponded with increased abundance and diversity of common species well-adapted to frequent disturbance by humans. Based on data gaps identified through their review process, Boyle and Samson concluded that primary shortcomings in the literature included a lack of experimental, rather than observational data, and a need to move from assessment of disturbance and mortality to analysis of long-term ecological effects (Boyle and Samson 1985).

A more contemporary review conducted by Larson et al. (2016) analyzed 280 articles on the effects of non-consumptive recreation and wildlife. This review was broader in scope than that of Boyle and Samson, including a wider swath of recreational activities and all taxa globally. Although these results are not directly comparable due to differences in scope, Larson et al. identified similar trends to Boyle and Samson 31 years earlier. The researchers found that articles remained mostly observational, with only 30% of articles containing an experimental component. Among the articles included in their review ( $n = 280$ ), mammals were studied the most often (114, 42%), followed closely by birds (101, 37%). A wide gap was observed between mammals and birds and invertebrates (34, 12%), herpetofauna (17, 6.2%), and fish (14, 5.1%). Notably, the authors found that the majority of species studied with International Union for Conservation of Wildlife (IUCN) status were classified as species of least concern, and that endangered, critically endangered species, and data-deficient species were the least often studied. Similar to Boyle and Samson, most studies evaluated identified significant effects of non-consumptive recreation on wildlife, with negative effects being the most frequent. Most studies that showed unclear results as to whether effects were positive or negative had a behavior-based response variable, demonstrating the challenges associated with interpreting behavioral responses (one of which is the potential for wildlife to habituate to recurring, non-threatening recreational use), and the implications for long-term ecology and land management (Larson et al. 2016).

Most studies on the effects of non-consumptive recreation on wildlife were conducted

in North America (Larson et al. 2016). In a paper on recreation impacts on wildlife submitted to the federal Interagency Visitor Use Management Council (IVUMC), Marion (2019) summarized the current state of research, with results falling into five broad categories. The categories included: 1) type of recreational activity; 2) recreationist behavior; 3) impact predictability; 4) impact frequency and magnitude; and 5) impact timing and duration. In regard to category one, Marion found mixed results on impacts from slow versus fast (e.g., walk, run, mountain bike, motorized vehicles) recreation activities. Regarding category two, he found visitors who directly approach wildlife are perceived as threatening, and wildlife are less disturbed by recreation travel that is slow, quiet, and in directions parallel to or away from them. Marion also found that wildlife are able to adapt to and tolerate consistent nonthreatening recreational activities, but unpredictable recreational activity in less visited off-trail locations can cause greater impact (category three). Repeated human interaction and disturbance of wildlife can exceed a threshold of tolerance that causes wildlife to leave a preferred habitat (category four). In regard to category five, Marion found wildlife show locational and seasonal sensitivities to recreation. Marion then describes multiple strategies to manage recreation to minimize impacts on wildlife, which are summarized later in this paper.

### **California-focused research**

California plays an important role in this body of research due to its abundant biodiversity and large areas of protected and/or publicly-owned lands. California has been relatively well-studied, with most research focused on birds, and more recently mammalian carnivores. The discussion below is not intended to be exhaustive but rather to summarize the findings of representative research efforts with implications for recreation and wildlife management and provide context for on-the-ground practices and recommendations, with a focus on California.

In the San Francisco Bay Area, several studies on avian wildlife have emerged in recent years. A 2008 study on foraging shorebirds and trail use found no change in behavior or species diversity during trail use (Trulio and Sokale 2008). These findings indicate foraging shorebirds at regularly used trails may habituate to human activity. However, other experimental studies have found that shorebird numbers decreased with human presence on trails (Trulio et al. 2013), and that trail uses such as jogging and dog walking can increase flight distance (Lafferty 2001). Differences in shorebird response to human disturbance are likely attributable to the birds' degree of habituation to human disturbance. Studies indicate that shorebirds in areas of more frequent human disturbance display less response to human activity; although, birds tend to use these areas at lower rates than areas with less disturbance (Josselyn et al. 1989). Trulio et al. (2013) recommended keeping trail users at least 50 m from foraging habitat. They also suggested that infrequent trail use may be more disruptive to birds than frequent trail use, indicating that habitation may occur as referenced above. Similarly, Miller et al. (1998) found the composition and abundance of birds to be altered in a Colorado grassland and forest setting, with an area of influence of approximately 75 m (zone where human activity may displace wildlife from suitable habitat).

As exemplified by these studies, even the least intrusive non-consumptive recreational activities, such as hiking and picnicking, have the potential to affect wildlife. Reed and Merenlender (2008) examined this possibility in the context of mammalian carnivores in the Northern San Francisco Bay Area. They consistently found that sites where quiet, non-

consumptive recreation is permitted had lower density of native mammalian carnivores than areas with no recreation. All recreational sites showed a shift in carnivore detections toward non-native carnivores such as domestic dogs and cats (Reed and Merenlender 2008). These results corroborate the relatively consistent finding that the mere presence of humans and their introduced domestic species may prove detrimental to native wildlife, regardless of the types of recreation in which they engage.

The finding that community composition shifted toward non-native species such as domestic dogs where recreation was permitted suggests a need to better understand the effects of dogs on native wildlife and the efficacy of various dog management strategies. This need is furthered by the outsized role dogs tend to play in open space management efforts. To follow up on their previous findings, Reed and Merenlender (2011) further studied the effects of different dog management policies in recreation areas. They found no significant differences in mammalian carnivore abundance or species richness between recreational sites with no dogs, sites with on-leash dogs, and sites with off-leash dogs. They did, however, identify significant differences between all three types of sites and reference sites with no recreation, suggesting that the presence of humans is a more important influence on species diversity and carnivore density than that of dogs (Reed and Merenlender 2011).

## **MANAGING PUBLIC ACCESS TO PROTECT WILDLIFE**

To better understand whether trends identified in the literature are translated to open space management practice, we obtained information from local park, recreation, and open space area managers on how they address public access and its potential impacts on wildlife. Due to the abundance of literature focusing on the region and the richness of open space availability and biodiversity in close proximity to urban populations, we focused this effort on the San Francisco Bay Area.

### **Case study on San Francisco Bay Area open space management strategies**

To assess current practices in addressing biological constraints in public access management and to identify how principles elucidated in the literature are applied in practice, we conducted a case study based on information obtained from ten open space management entities in the San Francisco Bay Area. Four of these were special districts, four were county agencies, and two were non-profit organizations. Each organization is identified numerically in the following discussion for the purposes of anonymity. All organizations were contacted by email in September 2019 and provided a survey with a standardized set of questions on public access management approach in areas known to contain sensitive biological resources. Each organizations' webpage was subsequently queried for supplemental information.

Five of ten organizations contacted via email responded to initial outreach efforts. Of these, three indicated that they restrict recreational access to some or all of their lands based on the presence of sensitive biological resources (County Two, Special Districts Two and Three). The other two respondents said they do not restrict access on any of their lands (Special District Four) or that they entitle open space preserves but do not hold land in the long-term or provide access opportunities (Non-Profit One).

County Two's response suggests limitations in their capacity to restrict public access for the purposes of addressing biological constraints. This County was in the process of de-

veloping a dog policy to determine where dogs are permitted and where leashes are required. In describing this policy, County Two representatives did not specify any biological factors being considered. Outside of its dog policy, the County indicated that they may restrict park access due to wet weather or public safety concerns; but that they generally do not restrict access for biological reasons apart from seasonally fencing off a small portion of one park for nesting shorebirds. In describing their shorebird protection efforts, representatives stated that they only restrict access insofar “as that is allowed.”

Webpage queries of all 10 organizations demonstrated that a management approach similar to County Two’s was common. There was little indication of restricted recreational access such as permit-only areas or seasonal park or trail closures to address biological constraints, with dog policies being the most common strategy to protect wildlife. Most permits were related to facility rental or special event production, with some parks containing sensitive plant species also providing scientific collection permits. Furthermore, most seasonal trail closures cited severe weather and trail washouts, and few were explicitly tied to biological concerns. Among the organizations surveyed, restricting the presence of dogs in parks was the most common strategy used by land managers to reconcile potential incompatibilities between non-consumptive recreation and sensitive species protection. Virtually all organizations had some type of dog policy in place or were in the process of establishing a dog policy. More than half of them specifically cited disturbance of wildlife or other biological constraints when describing dog access restrictions. Policies ranged from outright prohibition of dogs to requirements that dogs be kept on leashes.

Special District One was a notable exception to the patterns described above. In addition to restrictions on dogs, this organization employed a variety of methods, including permit-only access areas and seasonal trail and road closures. Special District One maintains one area that can only be accessed by permit holders. This area provides habitat for special-status avian species and other non-special status wildlife species. Recreational activities in this area are restricted to camping, hiking, horseback riding, and backpacking, and permits must be purchased in advance. Hunting is not allowed. Additionally, Special District One closes portions of one park annually for raptor nesting, and at the time of writing, one other park had trail closures for unspecified habitat protection. Special District One indicated in its response to outreach efforts that it annually and occasionally employs this technique as needed, closing trails and roads based on the presence of wildlife during sensitive windows such as nesting or mating. Moreover, correspondence with this District indicated that they purchase lands in collaboration with conservation organizations and place these lands under easement, and that when these lands become publicly accessible, permissible recreational activities are limited to those compatible with applicable habitat conservation plans. In addition to these strategies and similarly to other organizations, Special District One provides restrictions on where and how dogs may be present on their land. Biological considerations incorporated in this District’s dog policy included prohibition on dogs where specified by conservation easements and in sensitive habitats such as marshes and wetlands.

The two non-profit entities included in this study had management practices that were among the most wildlife-protective. Non-Profit One indicated that opportunities for public access on their lands are very limited due to their high conservation value and the organization’s emphasis on preserving biodiversity—suggesting an approach placing higher value on conservation than recreation and incidentally allocating recreational opportunities where compatible with biological constraints. Perhaps the most unique management strategy



identified in our case study was employed by Non-Profit Two. This organization divided their lands into two distinctive types of preserves—with the primary purpose of one type being public outreach and education, while the other type primarily served conservation purposes. While conservation and restoration activities are held on both types of preserve, the former includes more opportunity for educational events, hiking, and community volunteer days than the latter, where public access is limited due to resource constraints.

In our outreach and website queries, we looked for permit-only access areas, seasonal trail closures, restrictions on dogs, and other management strategies. Few of the public entities included in this case study restricted recreational access permanently or seasonally to address biological constraints, with surveyed non-profit organizations doing so more holistically. Yet, most public entities indicated the presence of sensitive plant or animal species on their lands or stated conservation as one of their organization's purposes. Although this case study examines a small, non-representative sample of management entities, these findings suggest that the public land management agencies that responded to our query may be constrained by mission and purpose in their ability to limit public access relative to other organizations such as non-profits with a singularly focused purpose of resource protection.

### **ADDITIONAL RESEARCH NEEDS**

Several implications emerge from our review: 1) research efforts need to extend beyond noting individual behavioral responses; 2) more research is needed on species beyond birds and mammals; and 3) impact studies need to be more frequently integrated with research on outdoor recreation use patterns.

The studies we reviewed indicate that although some research has been conducted on the effects of non-consumptive recreation on wildlife, the scope is generally narrow. There is a need for additional information on other taxa, given the number of listed species that are not birds or mammals. Moreover, recreational impacts on special status plant species are consistently less studied than those on wildlife, despite the high number of listed plant species, and the fact that habitat degradation (including impacts to vegetation) is a potential mechanism for recreation's impacts on wildlife. One example of such an investigation is the Spring Mountains National Recreation Area Landscape Analysis (USDA 2008). This report included an evaluation of spatial impacts from current and future recreation facilities on habitat loss for 30 special status species, most of which were plants. Another example is the Marin County Road and Trail Management Plan (Marin County Parks and Open Space District 2014) which included an analysis of illegally constructed mountain bike trails on special status species, most of which were plants.

Our findings suggest that individual wildlife response to recreational activity is studied more often than population-level response. One exception is experimental, longitudinal research conducted by Riffell et al. (1996), who evaluated the effects of repeated intrusion by hikers to avian communities in Wyoming's Medicine Bow National Forest for 10 weeks during the breeding season over 5 years. Their study found no cumulative or yearly declines in seasonal species richness, mean richness, or mean total abundance. They did find that repeated intrusions altered the composition of the community represented by the most common species, but no widespread impacts on avian community structure were documented. Continuing this line of research will be important to evaluate recreation impacts at the population level. This is particularly crucial given the nature of Federal and State regula-

tory schemes for endangered species, which typically take a population-based approach to species protection. Moreover, conducting research at the population level eliminates the need to interpret individual-level responses' implications for broader conservation efforts. Extrapolating individual response to a population-level context can prove difficult (Bejder et al. 2009; Caro 2007), and eliminating the need to do so reduces uncertainty for decision-makers.

Population-based outcomes should continue to be incorporated in future studies to facilitate stronger understanding of recreation's implications for conservation. While this is a more difficult undertaking than simply investigating behavioral responses, this type of research is needed to inform policies implemented by land managers. Useful models for conducting long-term, quasi-experimental research that addresses the larger question of population viability in the context of known threats, including non-consumptive recreation, to special status species exists in previous studies and can be used to inform future research.

Additionally, the taxa studied need to be prioritized to include additional groups. Mammals and birds have been studied more often than other taxonomic groups since non-consumptive recreation became a popular topic of research in the 1980s, and continue to be the most studied today. This does not necessarily correspond with greater conservation or research needs, especially considering the high number of amphibian, reptile, and invertebrate species with special status as designated by the California Department of Fish and Wildlife or the U.S. Fish and Wildlife Service (~61% of listed species in California). If park and open space managers are to make informed, high-impact conservation decisions using the limited resources available to them, research efforts must be prioritized based on conservation need rather than focusing on the most visible species. Similar work is needed to provide frameworks for prioritizing research dollars in wildlife and open space management.

Before embarking on a new vein of research to address these above areas, it may be useful to consider comments offered by Dr. David Cole and William Hammitt, from their textbook, *Wildland Recreation: Ecology and Management*. From Hammitt and Cole (2015):

The relationship between amount of recreational use and wildlife impacts is not well understood. Very few studies have systematically examined the effects of varying numbers of visitors on wildlife. Even fewer wildlife studies have determined an accurate population count of organisms prior to the introduction of recreation.....Previous research indicates the complexity of the relationship by stating that the number of visitors cannot be considered in isolation from species requirements and habits, setting attributes, and type of recreational use. Various aspects of use intensity are also involved, including frequency and regularity of use and number of people at one time.

Thus, the third area where additional research is needed is integrated research that links specific outdoor recreation patterns to effects on species distribution and abundance. Some of this is occurring via research by Larson, Reed, Merelender, and others. For example, Larson et al. (2018) correlated recreational use levels with habitat occupancy for seven special status species for 18 reserves in San Diego County. This is a thorough research effort that integrates a model to predict recreation use levels with whether habitats for special status species are occupied. A more comprehensive and robust effort is needed that extends this type of research to a variety of habitat types and recreational use levels

throughout California. Finally, the effectiveness of the “regulatory toolkit” that park, recreation, and open space managers have to control outdoor recreation use is well-established for federal lands, but its applicability to protected areas in close proximity to urban areas is largely unknown. Marion (2019) mentions strategies on how to address recreation impacts to wildlife including: reducing use, modifying the timing and location of use, modify the type of use, visitor behavior and expectations, and maintain and/or rehabilitate the resource. In regard to modifying visitor behavior, there is an entire body of research that focuses on how well visitors comply with wilderness and other protected area regulations (Lucas 1981; Washburne 1982; Duncan and Martin 2002; Marion and Dvorak; Martin and McCurdy 2010), and a review of low impact education programs (Marion and Reid 2007), such as Leave No Trace, suggests these programs can be effective at altering visitor behaviors that can cause impacts to natural resources. However, what has not been well investigated is how widespread such programs are implemented by park, recreation, and open space managers, and their applicability to open space preserves near urbanized areas.

Furthermore, it is important for research to go beyond theory and be adopted into practice by land managers. Research findings must be placed into a conservation and management context, with actionable priorities and recommendations for park, recreation, and open space managers. Researchers should engage with park and open space managers to ensure that science-based policies are enacted. Although limited in scope, our case study indicates some potential disconnects exist between the scientific community and on-the-ground open space management entities. For example, a large portion of the San Francisco Bay Area open space management and wildlife conservation efforts focused on developing sound dog policies; yet our research on the matter suggests that the effects of dogs are secondary to those of the presence of humans. Therefore, it may be of higher impact to examine ways to limit human activity in areas with sensitive biological resources through trail routing, permanent and seasonal park closures, and other methods.

Researchers and managers should therefore work together to develop, implement, and test science-based strategies. Social science-based methods should be included when testing approaches to better understand compliance with and attitude towards various management approaches as well as park use patterns. Several studies described above (Duncan and Martin 2002; Martin and McCurdy 2009) integrated these methods into their research but were focused on compliance with wilderness regulations.

Taylor and Knight (2003) demonstrated a potential approach for researchers to integrate study of park user perceptions into their work. They used a behavior-based model to study ungulate response to hikers and mountain bikers in a state park in Utah and, importantly, analyzed visitors’ perceptions of their own effects on wildlife. They found that recreationists tend to attribute adverse effects on wildlife to other recreationists’ actions and not their own. These results illustrate the importance of park user education as well as collaboration between the natural and social sciences in recreation and wildlife management.

Another example may be found in research conducted by Jefferson County Open Space District in Colorado, which has documented “heat maps” of recreation use for trails that bisect their open space areas. This information can then be overlaid with known or potential occurrences of special status species. Accurately collected recreation use data such as these would help biologists and park and open space managers better understand the relationship between overall park use patterns and wildlife impacts, an area of research that we found to be notably understudied.

To move toward sound management practice that effectively accommodates demand for public access and need for species protection, methodological changes and research prioritization are needed. Through review of literature related to the effects of non-consumptive recreation on wildlife and a survey of local agencies' integration of science-based methods into open space management efforts, we found that significant data gaps exist in both science and policy. New frameworks are needed to prioritize conservation efforts, which identify sensitive resources and integrate these into management efforts. Additional research using population-based response variables is necessary to quantify effects and determine whether management strategies are effective. A holistic approach incorporating conservation status and public recreational use patterns is needed to prioritize finite research and management resources.

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#### Author Contributions

Conceived and designed the study: JB

Collected the data: AS

Performed analysis of the data: AS

Authored the manuscript: JB, KD, AS

Provided critical revision of the manuscript: JB, KD, RC

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## Wildlife occupancy and trail use before and after a park opens to the public

SUSAN E. TOWNSEND<sup>1\*</sup>, STEVEN HAMMERICH<sup>2</sup>, AND MICHELLE HALBUR<sup>2</sup>

<sup>1</sup> *Wildlife Ecology and Consulting, 709 56th Street, Oakland, CA 94609, USA*

<sup>2</sup> *Pepperwood Foundation, 2130 Pepperwood Preserve Road, Santa Rosa, CA 95404, USA*

\*Corresponding Author: [suetownsend@earthlink.net](mailto:suetownsend@earthlink.net)

We investigated changes in wildlife trail use and occupancy from baseline conditions after a park opened to the public; we were curious if wildlife would alter either their use of the trails or the surrounding areas or both in response to the park opening. We generated single-season occupancy estimates as a site-wide occupancy metric from 23 camera traps placed at 0.5 km intervals throughout the park and wildlife and human detection rates to measure intensity of trail use from 10 camera traps placed every 500 m on the trail. We compared the findings from the four seasons before to the four seasons after the park opened to the public. Human trail use increased sharply after opening and then lessened, but was markedly higher than prior to opening. Bobcat (*Lynx rufus*), coyote (*Canis latrans*) and gray fox (*Urocyon cinereoargenteus*) did not alter trail use relative to study area occupancy. Two species, black-tailed deer (*Odocoileus hemionus*) and gray squirrel (*Sciurus griseus*) altered trail use, and puma (*Puma concolor*) and wild turkey (*Meleagris gallopavo*) altered both trail and study area use. All species, except for the raccoon (*Procyon lotor*) and wild turkey, recovered to pre-opening conditions, by the winter (that is, after approximately 9 months) following opening.

Key words: camera trapping, occupancy, open space, recreational impacts, trail use

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Protected open space is considered important for conserving wildlife and providing public recreational opportunities in the San Francisco Bay Area. Recreation is often supported by concomitant trails and infrastructure, that is, that existing trails and fire roads are used by the public and, in turn, additional infrastructure is required to facilitate access. To conserve wildlife effectively, it is important to understand how wildlife may be affected by human use of the landscape even when those uses appear benign. Wildlife often share the use of trails with humans, their dogs, cyclists, motorized vehicles, and equestrians, while also

preferentially using roads and trails for movement (Whittington et al. 2005). The extent to which non-motorized recreational human uses impact wildlife that rely upon open space (for breeding, movement, foraging, etc.) is the subject of this study. Wildlife may be disturbed by human presence on trails and, as a result, vacate the surrounding landscape despite the landscape's capacity to support them. An alternate scenario may be that wildlife avoid or reduce trail use (that humans are using) but remain resident in the surrounding landscape in response to human trail use.

Wildlife can be both negatively or positively associated with human presence and zones of urbanization. Recreation has been shown to have behavioral impacts on wildlife, such as reduced feeding times (Cassirer et al. 1992), detrimental stress responses (Barja et al. 2011), reduced temporal occupancy (Wang et al. 2015), but also the reverse (Ordeñana et al. 2010; see also Reilly et al. 2016 for a review of the literature). With pressure on open space providers to accommodate human recreation and increase accessibility, understanding how access and intensity of human use affects wildlife provides essential information towards making decisions that effectively balance wildlife conservation with human interests.

We examined how public presence may affect wildlife trail use and occupancy in the surrounding landscape in the North Sonoma Mountain Regional Park and Open Space Preserve (hereafter, "Park/Preserve") in southeastern Sonoma County, California. A camera trapping array (grid) encompassed the Park/Preserve to assess changes in single season occupancy estimates (that is, we use occupancy as an index of prevalence or a surrogate of abundance in the study area; O'Brien et al. 2010; Royle and Nichols 2003; MacKenzie and Nichols 2004; MacKenzie et al. 2006; but see Burton et al. 2015 and Steenweg et al. 2018, 2019 for cautionary discussions). Additional cameras were placed on the trail to assess wildlife and human use (that is, through detection rates as a measure of intensity of use); trail construction had been completed by the time the study began.

Below we outline the key hypotheses to address the following question: How does human trail use affect wildlife trail use and occupancy in the study area?

H<sub>0</sub>: Wildlife did not change their use of trails or residency (abundance) within the Park/Preserve after it is opened to the public. Wildlife occupancy estimates (abundance) from the grid and the trail detection rates do not change after the Park/Preserve opens to the public.

H<sub>1</sub>: Wildlife use trails less but are still resident within the study area after the Park/Preserve is open to the public. Wildlife trail detection rates decrease after human trail use increases but occupancy estimates (abundance or residency) does not change in study area after the Park/Preserve opens.

H<sub>2</sub>: Wildlife reduce trail use and vacate the study area after the Park/Preserve is open to the public. Both wildlife trail detection rates and site-wide occupancy decrease within the Park/Preserve after it opens to the public.

H<sub>3</sub>: Certain types of wildlife (e.g., carnivores or ungulates) may be differentially affected by the presence of humans. With regard to trail and Park/Preserve use, see H1 and H2.

H<sub>4</sub>: Wildlife resume a similar intensity of trail use and abundance within the study area after a period of time post-opening compared to pre-opening measures (latency to habituation). Wildlife trail detection rates decrease initially after opening, but then return to the pre-opening levels after a period of time. If wildlife do leave the study area for a period of time (lower abundance), these measures (trail detection rates and occupancy estimates) will both decrease initially after Park/Preserve opening but then recover to pre-opening levels.



## METHODS

### Study area

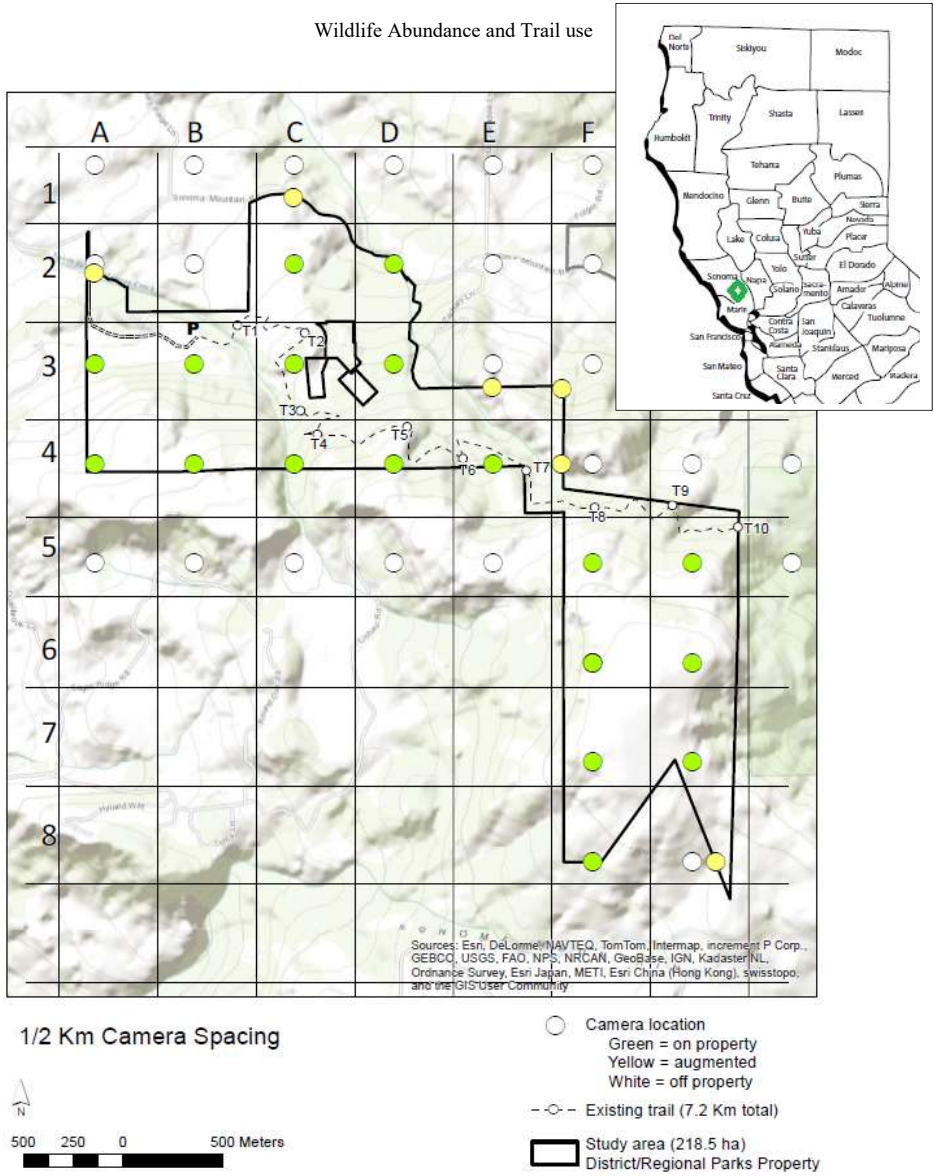
The 3.4 km<sup>2</sup> study area, North Sonoma Mountain Regional Park and Open Space Preserve (Park/Preserve; 38.3235 N, 122.5756 W, [parks.sonomacounty.ca.gov/Visit/North-Sonoma-Mountain-Regional-Park/Park-Map/](https://parks.sonomacounty.ca.gov/Visit/North-Sonoma-Mountain-Regional-Park/Park-Map/)) is located in Sonoma County, California, USA (Figure 1). Sonoma County Agricultural Preservation and Open Space District (SCAPOS) acquired the property and built the 5.95 km trail that ranges in elevation from 244 m to 750 m between June 2010 to September 2012. The Park/Preserve was then transferred to Sonoma County Parks in 2014 and opened to the public on 14 February 2015. Cattle grazing occurred before and during the study in portions of the site that supported grasslands; the site had no exclusionary fencing dividing up the site.

This area is subject to a Mediterranean climate characterized by wet, cool winters and dry, hot summers. Habitats included non-native grasslands (warm grasslands), oak-bay woodland (montane hardwood), redwood forest, mixed forest with madrone (montane hardwoods), and remnants of coast live oak forest/woodland and California bay forest (Biodiversity Portfolio Report, <https://www.bayarealands.org/explorer/#>, Conservation Lands Network Explorer 2016, 1 December 2016; Bay Area Open Space Council 2011). Matanzas and South Fork Matanzas creeks run through the study area. The topography is characterized by the steep hillsides of Sonoma Mountain. The surrounding land use matrix is composed of low-density rural development, protected open space, vineyards, and grazed grasslands.

### Study design

A north-south grid of 23 motion and heat-differential triggered camera traps, HCO SG550V IR Scouting Cameras [and replacement Bushnell Trophy Cams (model#119636c)] were set in a randomly-generated fixed array at 0.5 km intervals covering the entire Park/Preserve (“grid cameras”). We adjusted six camera coordinates by less than 200 m to fit within the study area prior to going in the field (see yellow circles on Figure 1). Species-specific single-season occupancy estimates were generated for four seasons before and after the Park/Preserve opened to the public (see Table 1). We placed ten additional cameras at 500 m intervals along the trail (“trail cameras”; Figure 1). We calculated seasonal trail detection rates (detections per 100 trap nights) as a measure of intensity of wildlife and human use for four seasons before and after the Park/Preserve was opened to the public (see Appendix I for a list of human use categories).

*Camera trapping methodology.*—We followed a camera trapping and data management protocol, which is a modified version from TEAM Network 2009 and O’Brien 2010. Grid cameras were uniquely identified by line letter and number (e.g., A1, A2, A3, etc.; Figure 1). We placed camera traps within 100 m of the pre-determined coordinate during field deployment. Camera traps were attached to a wooden stake or tree with a nylon strap. Camera height was standardized to detect a mammal approximately gray fox size at a distance of 2 m at a perpendicular angle. Eight of the ten trail cameras were mounted on trees, and, after the Park/Preserve opened, were outfitted with security boxes to prevent theft. We recorded location (GPS coordinates), habitat within which the camera was placed (open, closed, or mixed), and elevation during deployment. Habitat (vegetative structure) included just three



**Figure 1.** Camera layout for grid (yellow and green circles) and trail cameras (T1-T10) with study area location (green diamond in inset map of California counties); North Sonoma Mountain Regional Park and Open Space Preserve, California, USA, 2014-2016.

**Table 1.** Seasons before and after park opening, beginning and end dates for seasonal analysis, and effort (trapnights) for trail (n = 10) and grid (n = 23) camera arrays in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA, 2014-2016.

Before or after opening Park/Preserve	Season	Begin and end dates	Trail trapnights	Grid trapnights
Before	Spring	1 March–30 May 2014	591	1,251
Before	Summer	1 June–31 August 2014	601	1,266
Before	Fall	1 September–31 November 2014	656	1,508
Before	Winter	1 December 2014–13 February 2015	606	1,106
<i>Opening</i>		<i>14 February 2015</i>		
After	Spring	1 March–30 May 2015	245	1,019
After	Summer	1 June–31 August 2015	16	701
After	Fall	1 September–31 November 2015	540	1,200
After	Winter	1 December 2015–15 January 2016	146	587

categories: closed (closed canopy), mixed (mixture of open and some overhead canopy such as oak woodland intergrading with grassland or chaparral), and open (no overhead canopy usually grassland). All cameras were set to take three images per trigger (event), a five second interval between events, 6 MP image size, high sensitivity level, and time stamp “ON.” We adjusted image size and sensitivity as needed to match field conditions and improve data collection.

To verify camera station functioning during set up and maintenance, we took photographs of whiteboards with date, camera station identification, region, and subregion. We maintained camera stations regularly for proper functioning. We downloaded images from SD cards into a Windows Explorer embedded file system; EXIF image data was exported using PIE software (Picmeta v.6.75, [www.picmeta.com/](http://www.picmeta.com/)) into .csv files. We (authors and C. Lafayette) catalogued images to species or highest taxonomic order attainable; one of the authors (SET) vetted for accuracy during data preparation. Birds and other non-mammalian taxa were not identified to species nor included in the analysis. We categorized humans into several categories including pedestrian, cyclist, or equestrian (see full list in Appendix I). Unidentifiable images (“unknowns”) and blanks were recorded as such.

## Statistical analyses

We prepared a species detected list for the study area and trail compiled from before and after the Park/Preserve opened (Appendix I). We calculated single-season occupancy estimates from the camera grid and trail detection rates (detections per 100 trapnights) for terrestrial mammals (squirrel-size and larger) and wild turkeys (*Meleagris gallopavo*) from the cameras placed on trails (only). Trail cameras were not used in calculating occupancy estimates.

We calculated camera trap days (“trapnights”) as the number of 24-hour periods (0000 to 2359) that the camera trap was functioning for each season [spring (March-May), summer (June-August), fall (September-November), and winter (December-February)]. We aggregated trapnights by grid and trail (Table 1) and compiled detection histories for grid cameras.

We recorded detections as the maximum number of individuals for each species in an image in a burst of three (an “event”), which are taken when the camera trap was triggered by movement and/or heat differential. For example, in a burst of three images, one image recorded two deer, in the next, three deer and in the final image, a deer; 3 deer would be recorded for that detection (maximum number of individuals in an image detected during one event).

*Occupancy Analysis.*—An occupancy estimate ( $\psi$ ) for each species detected for the season was obtained using the program PRESENCE (v3.2, [www.mbr-pwrc.usgs.gov/software/presence.html](http://www.mbr-pwrc.usgs.gov/software/presence.html); Hines 2016). We used single-season occupancy models to estimate initial occupancy estimates ( $\psi$ ) and detection probabilities ( $\rho$ ) for each species (Mackenzie et al. 2003). Occupancy models account for imperfect detection and provide unbiased estimates of occupancy. To apply these models, detection histories were compiled for each species at each camera station as a series of ones (detection) and zeroes (non-detection). Each day (24-hour period commencing at 0000) the camera station was up was considered a (re)survey. Each day the camera station was “down” or not functioning was treated as a missing value.

Two pre-defined models were run, and the model with lowest delta Akaike’s Information Criterion (AIC) was used to estimate probability of detection and occupancy (Hines 2016). The first model assumes the same occupancy probability for all camera station locations and that detection probability ( $\rho$ ) was constant across both camera station location and survey occasions (i.e., two parameters). The second model assumes that all camera station locations have the same probability of occupancy ( $\psi$ ), but that  $\rho$  varies between the surveys—although at each survey occasion,  $\rho$  is the same at each camera station location. The software PRESENCE uses AIC to rank models (Burnham and Anderson 2002), which relies on rules of parsimony. In this case, twice the log-likelihood values at the maximum likelihood estimates were used to calculate the AIC values in model weighting.

*Comparison of seasonal occupancy estimates and detection rates.*—Single-season occupancy values were compared from the season before to the season after and plotted in a seasonal time series to compare to trail detection rates relative to occupancy estimates. We added linear trend lines in several time series figures to show trend from the first season (spring 2014) to the last season of the study (winter 2015-2016).

## RESULTS

We set up camera traps during February 2014 and maintained them regularly until the study ended in mid-January 2016. Camera placement elevation ranged from 252 to 737 m in closed, open, and mixed habitat. Of the 23 grid cameras, four (17%) were set in closed habitat, four (17%) in mixed, and 15 (65%) in open habitat; of the 10 trail cameras, five (50%) were in closed habitat, two (20%) in mixed, and three (30%) in open habitat. The trail was located largely within closed habitat. The Park/Preserve was open (warm grasslands, 50%) with remainder mixed and closed (41.8% montane hardwoods and 6% redwood forest; Biodiversity Report, [www.bayarealands.org/explorer/#](http://www.bayarealands.org/explorer/#), Conservation Lands Network Explorer 2016).

The composition of the wildlife community changed little from before and after the Park/Preserve opened (Appendix I). Common and expected species including large and medium-sized carnivores were detected; a California Species of Special Concern, the American badger (*Taxidea taxus*), was detected within the study area after the Park/Preserve was opened. Several rare and data-deficient species that may occur in this region were not

detected [e.g., the western spotted skunk (*Spilogale gracilis*), ringtail (*Bassariscus astutus*), porcupine (*Erethizon dorsatum*), and black bear (*Ursus americanus*)].

### Seasonal analysis and effort

We generated seasonal Park/Preserve occupancy estimates and trail detection rates for eight seasons (four seasons before and after, Table 1). Trail camera trap nights averaged 425 (range = 16–656) per season. Grid trapnights averaged 1,080 (range = 587–1,508) per season. Seasonal trapping effort varied due to stolen (and replaced) camera traps, data loss due to theft of SD cards, and increased trail use filling up the SD cards with images.

### Before and after seasonal comparison of occupancy estimates

Five wildlife species exhibited changes in occupancy estimates in the first season after the park opened; opossum increased (*Didelphis virginianus*) and raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), coyote (*Canis latrans*), and puma (*Puma concolor*) declined (Figure 2a) in the spring post-opening. Seven wildlife species exhibited changes in summer occupancy estimates; five decreased: striped skunk, gray fox (*Urocyon cinereoargenteus*), coyote, puma, and wild turkey (*Meleagris gallopavo*), and two increased [opossum and bobcat (*Lynx rufus*), Figure 2b] in the summer post-opening. Four wildlife species exhibited changes in occupancy estimates in the fall following opening; three decreased (gray fox, puma, and wild turkey) and one increased (opossum; Figure 2c). Only one wildlife species, raccoon, exhibited changes (increased) in occupancy estimates in the winter post-opening (Figure 2d).

### Trail use

Even though the trail was not officially open to the public, some pre-opening trail use by “humans” (pedestrians, staff and trail crew) as well as their dogs and cyclists was observed in consistently low numbers (Figures 3a-c). The Park/Preserve did not allow dogs, and dog detection rates remained low throughout the study period (Figure 3c). Human trail detection rates increased dramatically immediately after the park opened; 4,393 detections per 100 trap nights (spring 2015) from 148 the season prior to opening (winter 2014–15, Figure 3a). Cyclists increased from an average of 53 (range 4–64) pre-opening to 228 (range 77–338) post-opening. Aggregated wildlife trail detection rates decreased after Park/Preserve opening (Figure 3d).

### Comparing Wildlife Occupancy in the Park/Preserve and on the Trail

We compared wildlife species’ intensity of trail use (trail detection rates) with occupancy estimates seasonally before and after park opening.

*Black-tailed deer.*—Black-tailed deer occupancy increased post-opening (Figure 4a) and trail use decreased for two seasons then returned to pre-opening levels (see Figure 4b).

*Gray squirrel.*— Gray squirrel occupancy was stable both before and after the Park/Preserve opened to the public (Figure 4a). Gray squirrels decreased trail use post-opening summer, fall and winter from pre-opening levels (Figure 4c).

*Striped Skunk.*— Occupancy of striped skunks decreased (slightly) post-opening

Wildlife abundance and trail use

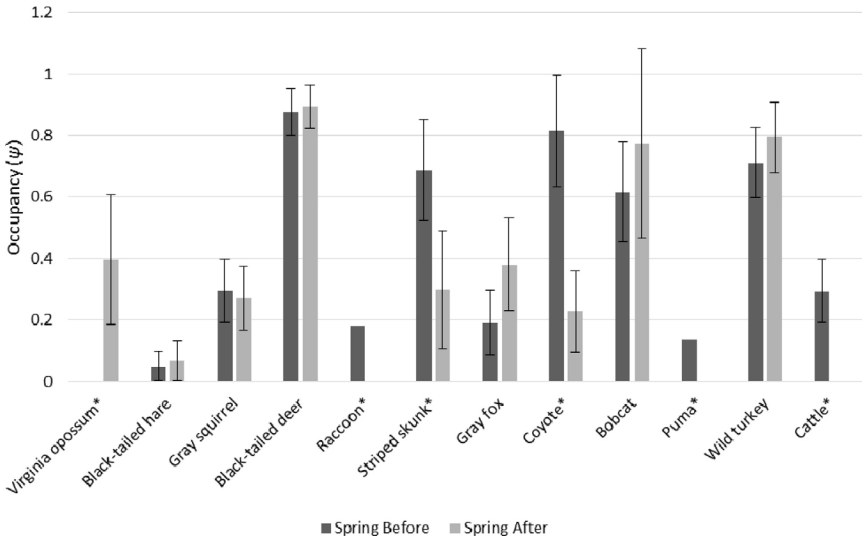


Figure 2a.

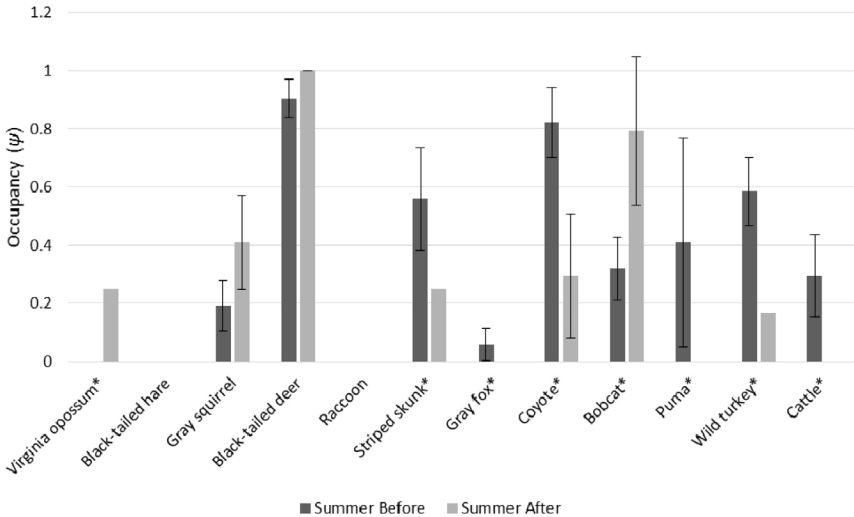


Figure 2b.

Figure 2a-d. Single-season occupancy estimates (error bars = ±SE) for wildlife species (\* = difference noted between before and after occupancy estimates) in the a) spring before (2014) and after (2015), b) summer before (2014) and after (2015), c) fall before (2014) and after (2015), and d) winter before (2014\_15) and after (2015\_16) in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA.

Wildlife abundance and trail use

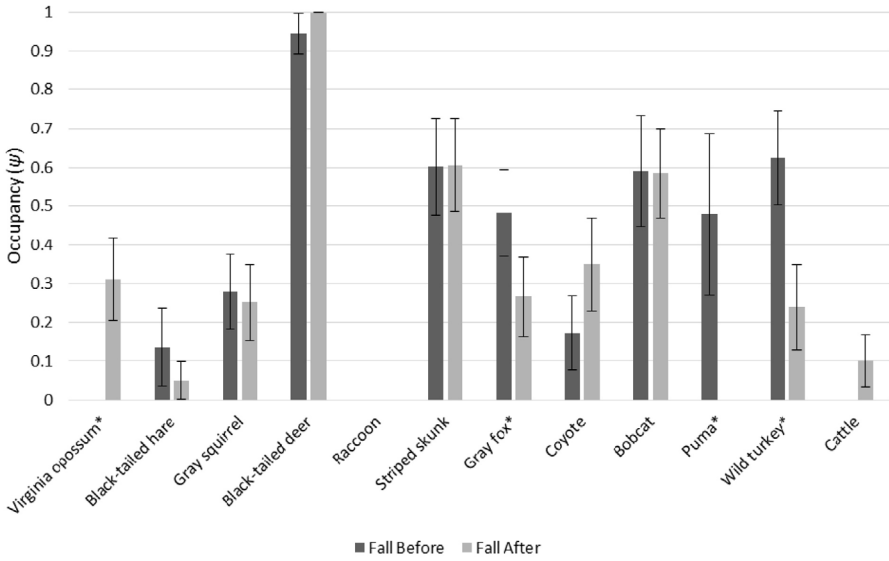


Figure 2c.

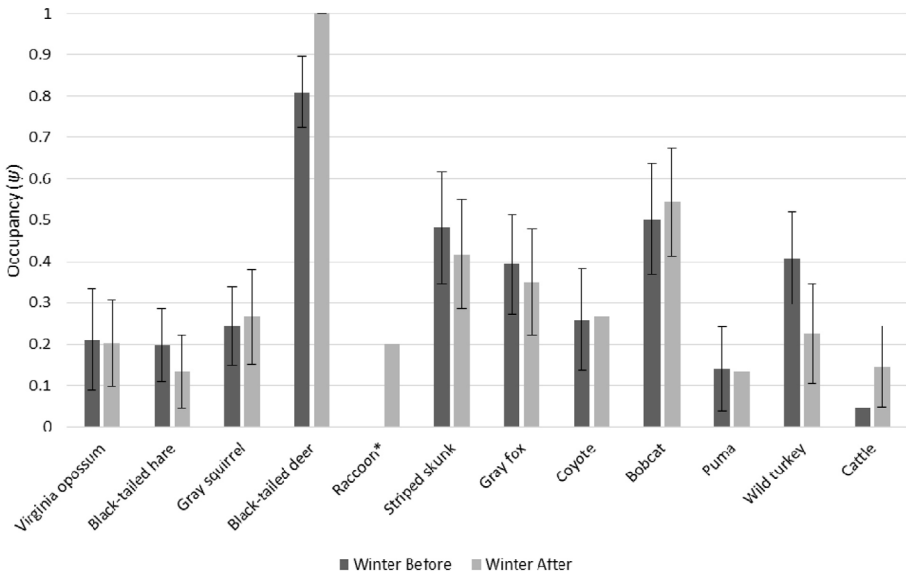


Figure 2d.

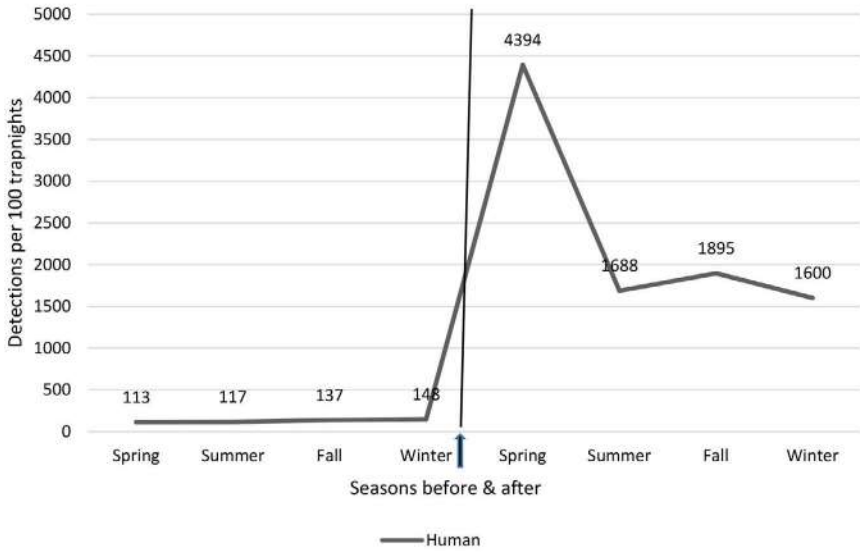


Figure 3a.

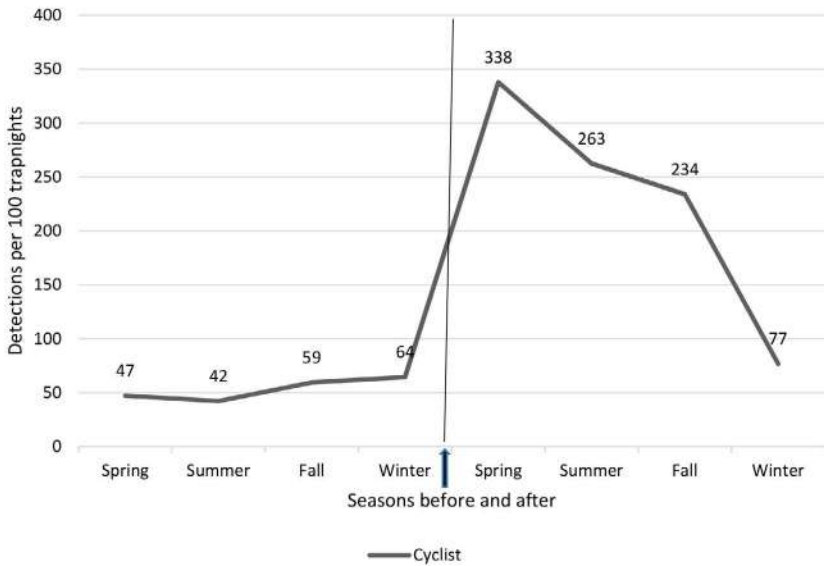


Figure 3b.

Figure 3a-d. Seasonal trail detections rates (detections per 100 trapnights) for before (spring 2014-winter 2015) and after (spring 2015-winter 2016) park opening (vertical line and arrow indicating 14 February 2015) for a) humans (non-cyclists), b) cyclists, c) domestic dog and livestock, and d) wildlife (linear = linear trend line) in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA.



Wildlife abundance and trail use

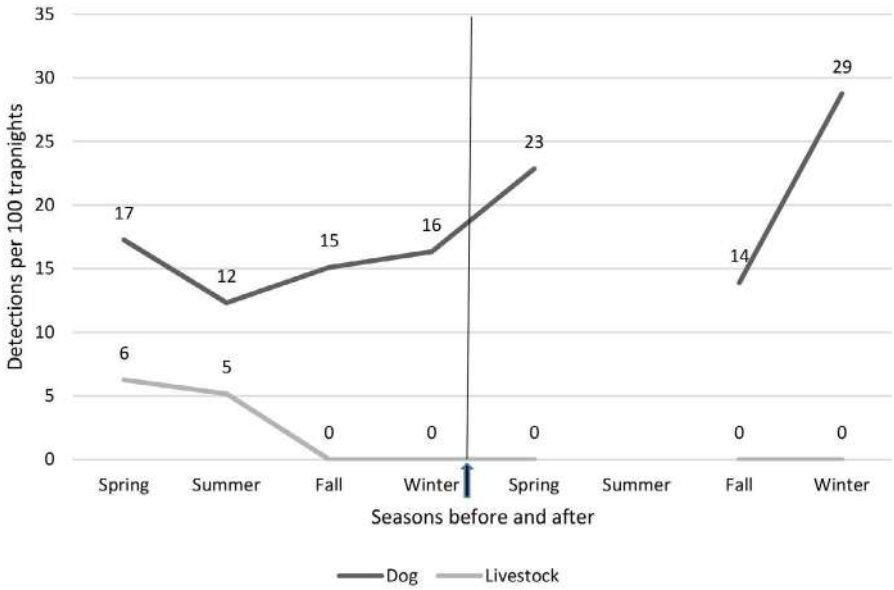


Figure 3c.

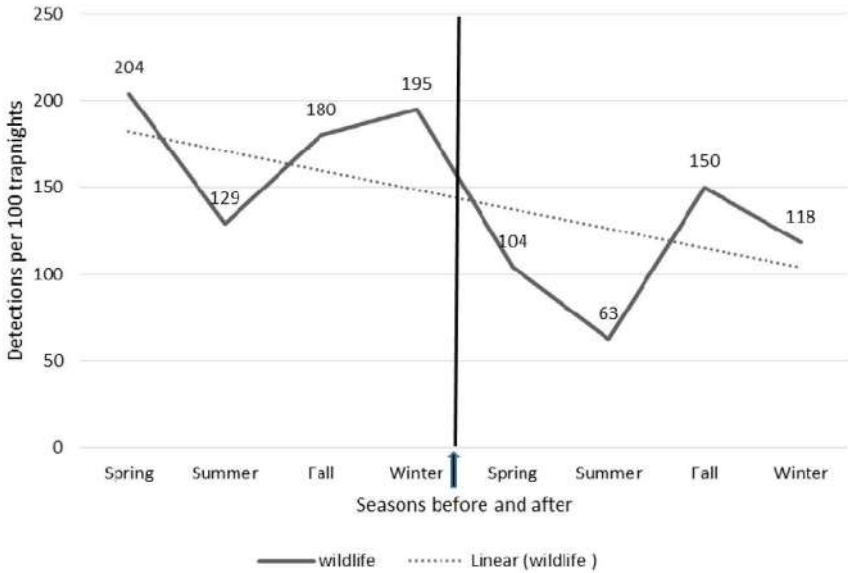


Figure 3d.

(Figure 5a). Striped skunk trail detection rates were the same post-opening for two seasons then increased to rates greater than pre-opening (Figure 5c).

*Wild turkey*.—Wild turkey increased in occupancy in the spring following Park/ Preserve opening and decreased trail use (detection rates) post-opening (Figure 5b and 5d). Wild turkey had lower occupancy estimates and trail detection rates for post-opening summer, fall and winter.

*Puma*.— Puma occupancy fell to zero post-opening then increased after 3 seasons ( $\psi = 0.13$ , Figure 6a), potentially indicating some latency to recover. Puma decreased trail use post-opening (Figure 6c).

*Bobcat*.—Bobcat occupancy increased slightly in the Park/Preserve (Figure 6b) and decreased slightly in trail use (Figure 6d) post-opening.

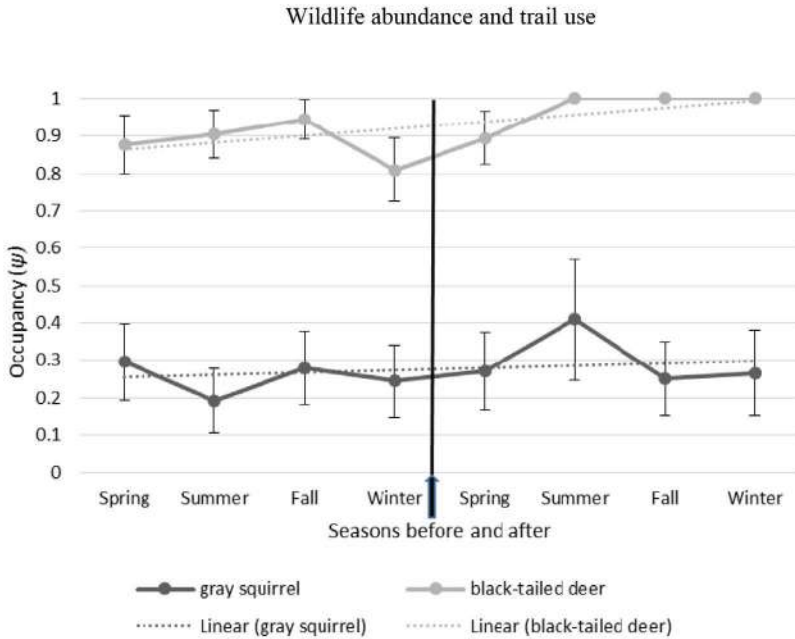
*Coyote*.— Coyote occupancy decreased prior to the Park/Preserve opening and then remained relatively stable (Figure 7a). Trail use remained stable with a slight increase post-opening (Figure 7c); trail use was similar to patterns of occupancy.

*Gray fox*.— Gray fox occupancy was stable and similar to pre-opening occupancy (Figure 7b). Trail use was similar to patterns of occupancy (Figure 7d).

## DISCUSSION

By our measures within this one study area, the wildlife that were the most affected by increased human trail use were puma and wild turkey, both decreasing in study area occupancy estimates, which we are using to detect changes in abundance and detection rates, which we are using as a measure of intensity of trail use. Additionally, the striped skunk notably increased trail use the third (fall) and fourth (winter) season after Park/Preserve opened. After two seasons post-opening, bobcat, gray fox, and coyote (three common mesocarnivores) appeared to be unaffected by public trail use both in abundance (as measured by occupancy estimates as an index of prevalence in the Park/Preserve) and trail use; these findings are consistent with a recent San Francisco Bay Area study (Reilly et al. 2016). The puma, which was present before the Park/Preserve opened, was then notably absent for three subsequent seasons post-opening. The majority of wildlife with the exception of the raccoon returned to previous occupancy levels the winter following opening (that is, after 9 months, Figure 2d).

Bobcat, coyote, and gray fox (mesocarnivores) showed little change in trail use, measured by camera detection rates on trail, and within the study area as indicated by by occupancy estimates from pre-opening measures, which support the null hypothesis,  $H_0$  (Table 2); that is, that public trail use (at the rates we measured) did not appear to affect these species. Deer and gray squirrel showed decreased trail use despite no change in study area abundance post-opening, supporting  $H_1$  that states that species change their trail use but not their overall use of the study area as measured by occupancy estimation. Puma and wild turkey decreased both trail use and abundance supporting  $H_2$ , which states that species will be affected by human trail use both on the trail and in the study area. Striped skunk increased trail use two seasons after opening and slightly decreased in abundance in the study area (see Table 2, Figures 5a and 5c). Deer may also have exhibited latency to habituation because their trail use resumed to pre-opening rates after two seasons (although it should be noted that human use declined; Figure 2a). Puma indicated latency to habituation for Park/ Preserve abundance (Figure 6a).



**Figure 4a.**

**Figure 4a.** Black-tailed deer and gray squirrel single-season occupancy estimates ( $\psi$ ; error bar =  $\pm$ SE, no error bar = no standard error) for seasons before (spring 2014–winter 2015) and after (spring 2015–winter 2016) opening (vertical line and arrow indicating 14 February 2015) in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA.

In contrast to our findings, Reed and Merenlender (2008) conducted a study in the same region and found coyote and bobcat scat prevalence, as an indicator of animal presence, to be five times lower in protected areas that allowed recreation compared to sites that did not. Reilly et al. (2016), however, point out that carnivore scats are problematic as a surrogate for carnivore density because domestic dogs can consume these scats. Additionally, the human ability to visually detect scat is extremely low when compared to trained scat dogs for this purpose (i.e., humans detect only a very small fraction of scat that are present; Smith et al. 2005, Oliveira et al. 2012). Our findings were consistent with Reilly et al. (2016) that mesocarnivores appeared largely unaffected by public access and, additionally, that striped skunks increased trail use with recreational trail use.

The puma is the largest carnivore in the San Francisco Bay Area and is thought to play an important role in the ecosystem. Pumas are used as a surrogate to examine overall connectivity in the landscape due to its large body and home range size. Wang et al. (2015) examined puma behavioral responses to development and roads. According to their study, communication and denning required a four times larger buffer from human development. Findings from our study show a pattern of avoidance, at least, initially; pumas were detected very infrequently or not at all from the study area with commensurate lower trail use for three seasons post-opening; this finding was in contrast to puma adults and young consis-

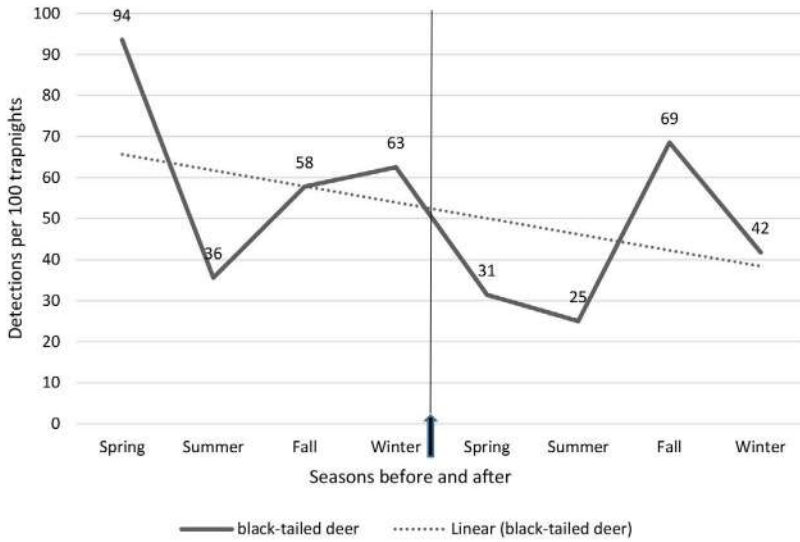


Figure 4b.

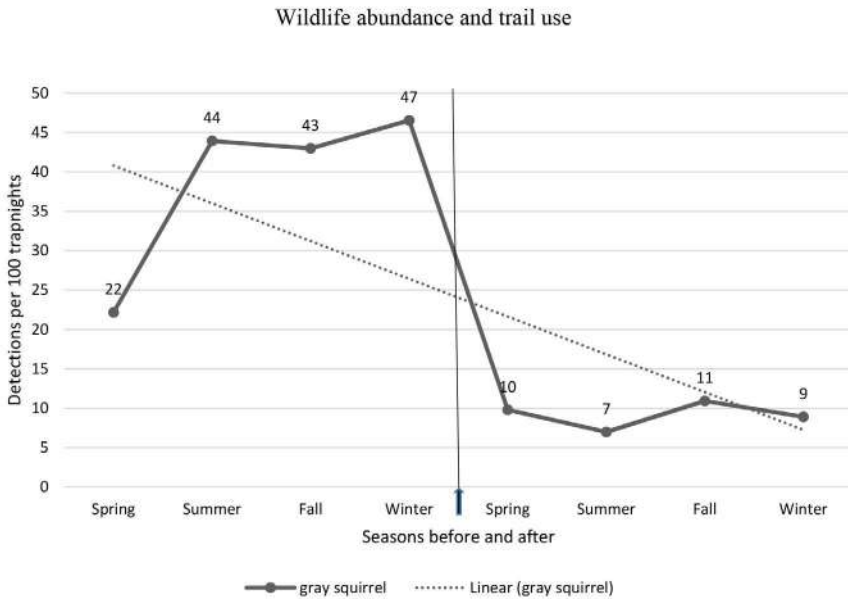


Figure 4c.

Figure 4b-c. Trail detection rates (detections per 100 trapnights) for b) black-tailed deer and c) gray squirrel for seasons before (spring 2014–winter 2015) and after (spring 2015–winter 2016) opening (vertical line and arrow indicating 14 February 2015) in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA. Linear indicates linear trend line.

Wildlife abundance and trail use

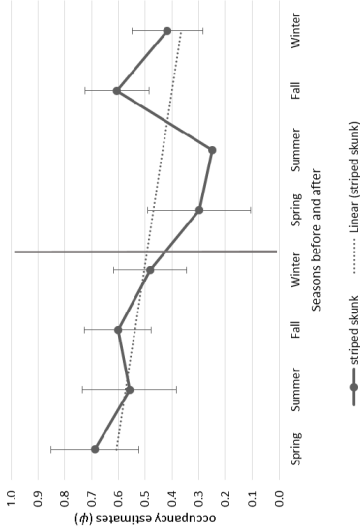


Figure 5a.

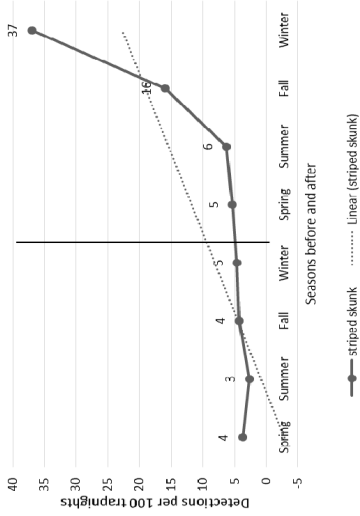


Figure 5c.

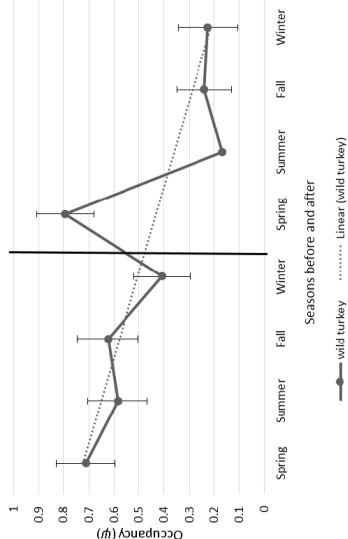


Figure 5b.

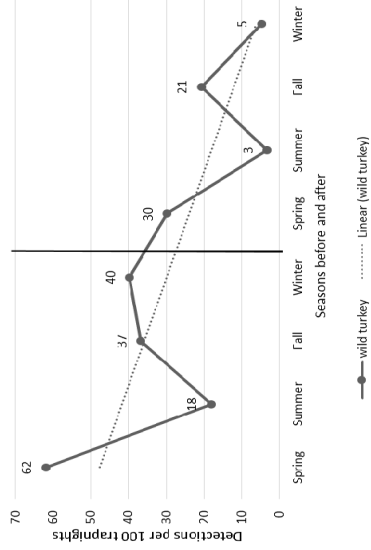


Figure 5d.

Figure 5a-b. Single-season occupancy estimates ( $\psi$ ; error bar =  $\pm$ SE, no error bar = observed occupancy) before (spring 2014–winter 2015) and after (spring 2015–winter 2016) opening (vertical line indicating 14 February 2015) for a) striped skunk and b) wild turkey in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA. Figure 5c-d. Trail detection rates (detections per 100 trapnights) before (spring 2014–winter 2015) and after (spring 2015–winter 2016) opening (vertical line indicating 14 February 2015) for c) striped skunk and d) wild turkey in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA. Linear indicates linear trend line.

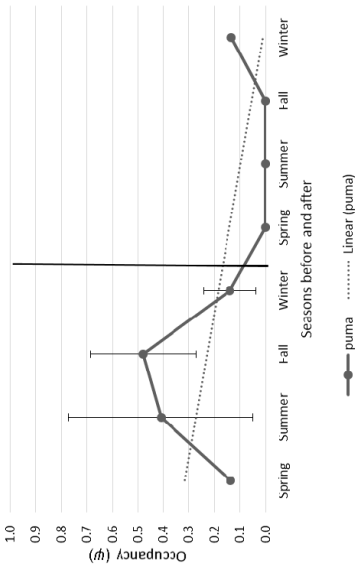


Figure 6a.

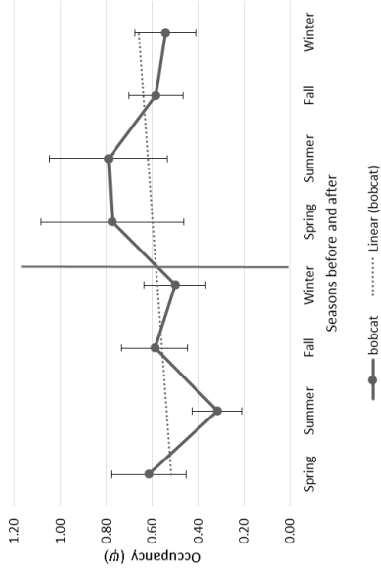


Figure 6b.

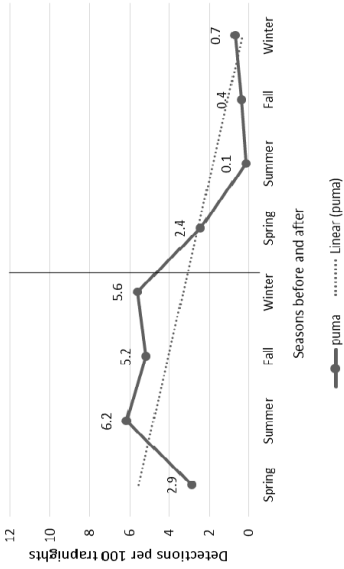


Figure 6c.

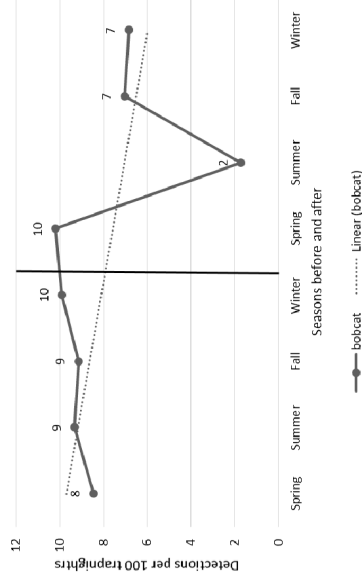


Figure 6d.

Figure 6a-b. Single-season occupancy estimates ( $\psi$ ; error bar =  $\pm$ SE, no error bar = observed occupancy) for seasons before (spring 2014–winter 2015) and after (spring 2015–winter 2016) opening (vertical line indicating 14 February 2015) for a) puma and b) bobcat in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA. Figure 6c-d. Trail detection rates (detections per 100 trapnights) before (spring 2014–winter 2015) and after (spring 2015–winter 2016) opening (vertical line indicating 14 February 2015) for c) puma and d) bobcat in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA. Linear indicates linear trend line.

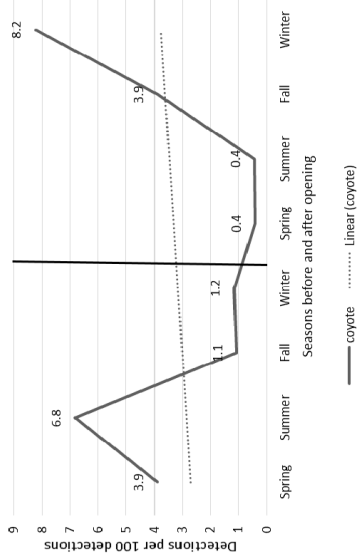


Figure 7c

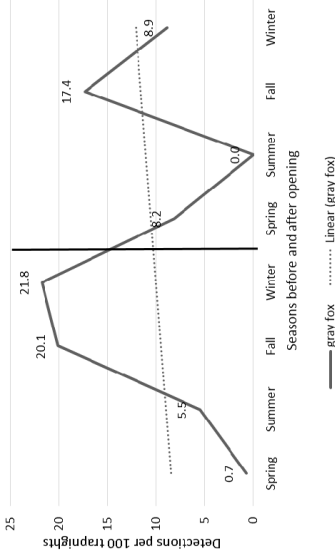


Figure 7d

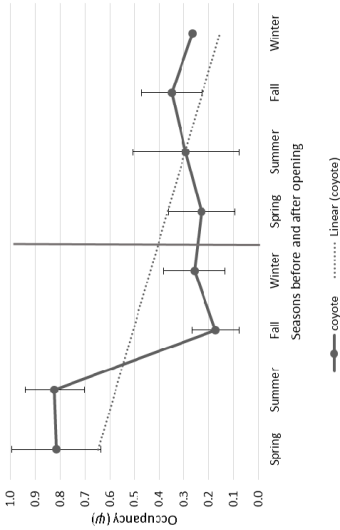


Figure 7a

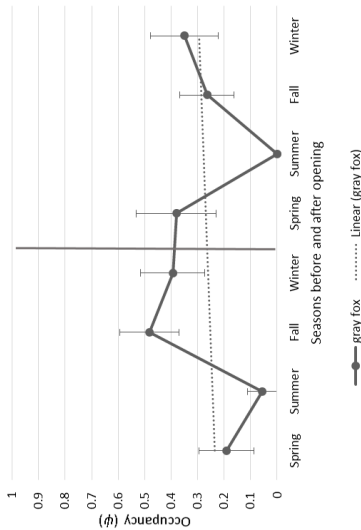


Figure 7b

Figure 7a-b. Single-season occupancy estimates ( $\psi$ ; error bar =  $\pm$ SE, no error bar = observed occupancy) before (spring 2014–winter 2015) and after (spring 2015–winter 2016) opening (vertical line indicating 14 February 2015) for a) coyote and b) gray fox in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA. Figure 7c-d. Trail detection rates (detections per 100 trapnights) before (spring 2014–winter 2015) and after (spring 2015–winter 2016) opening (vertical line indicating 14 February 2015) for c) coyote and d) gray fox in North Sonoma Mountain Regional Park and Open Space Preserve, California, USA. Linear indicates linear trend line.

**Table 2.** Which hypotheses are supported for selected wildlife species [Column headings: No change = no difference in trail use or Park/Preserve occupancy, Trail only = differences observed in trail use but not in Park/Preserve occupancy, Trail/Grid = differences observed in trail use and Park/Preserve occupancy, and Latency = recovery to pre-opening trail use and/or Park/Preserve occupancy values]. Under “Trail/Grid,” minus sign indicates a decline and a plus sign indicates an increase for each respective array. An “X” indicates findings support the hypothesis. North Sonoma Mountain Regional Park and Open Space Preserve, California, USA, 2014-2016.

Common name	Hypotheses			
	No change ( $H_0$ )	Trail only ( $H_1$ )	Trail/Grid ( $H_2$ )	Latency ( $H_4$ )
Bobcat	X			
Coyote	X			
Gray fox	X			X?
Deer		X		X
Gray squirrel		X		
Puma			X-/-	X?
Striped skunk			X+/-	
Wild turkey			X-/-	

tently present in all seasons before the trail opened. Camera trap images of puma from the pre-opening year frequently had a mother with cubs or almost fully adult offspring.

Our study area represents an area with low to moderate human disturbance (both recreational and agricultural); therefore, the wildlife in our study have had exposure to humans, roads and other infrastructure. Naïve wildlife from more pristine areas (free from human influence) may behave differently to human presence on trails and may be affected for longer period of time and in a larger area; this factor (exposure to human influence) should be accounted for when planning trails and increasing recreational access. Undeveloped open space surrounding trails provides a buffer so wildlife can (initially) move away from novel human presence or disturbance even if they are able to habituate to human trail use over time. Certain species such as pumas may require large trail free “zones” near trails to habituate over time and to successfully fulfill the full suite of life history activities such as hunting, reproduction and raising young.

Finally, for this specific study area and trail, wildlife was documented using trails even with a marked increase in human use (pedestrians, cyclists and equestrians); wildlife trail use did not drop to zero with the exception of wild turkeys and puma (at least for 3 of the 4 seasons following opening). Additionally, the apparent habituation after a period of time indicated that much of the local wildlife community, but not all, may be resilient to an increased presence of humans on a trail given time to adjust; it also should be noted that the cyclist detection rates decreased to pre-opening levels of use by the 4<sup>th</sup> season after opening, so as an alternative explanation, wildlife trail use may be able to tolerate relatively high levels of human use (1600 detections per 100 trapnights) with lower levels of cyclists (77 detections per 100 trapnights compared to a high of 338 after opening)



Land acquisition and preservation can go a long way toward ensuring future open space for wildlife; however, without commensurate wildlife monitoring, particularly for things like trail building and increased human access, with concomitant changes occurring in the surrounding landscape (e.g., traffic intensity, climate change, development, fencing), the actual benefit of that land to wildlife over time will remain unknown. From a management perspective, this “unknown” is a lost opportunity. Identifying thresholds of human use beyond which wildlife or particular species are unable to adjust may differ with various disturbance regimes and for different life history needs (e.g., foraging and movement versus breeding). Determining these thresholds and for which species are important next steps in understanding the impacts of recreationalists on wildlife. Through studies that capture pre-impact conditions as well as a post-impact timeframe that is meaningful for wildlife, open space effectiveness as a conservation tool can be measured, evaluated and improved.

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#### Author Contributions

Conceived and designed the study: SET

Collected the data: SET, SH, MH

Performed the analysis of the data: SET

Authored the manuscript: SET

Provided critical revision of the manuscript: SH, MH, SH

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**APPENDIX I.** Human categories and wildlife species detected before and after park opening in each camera array for the North Sonoma Mountain Regional Park and Open Space Preserve, California, USA, 2014-2016.

Common name	Species	Grid before	Grid after	Trail before	Trail after
Human Cyclist			•	•	•
Domestic cat	<i>Felis sylvestris</i>		•		
Domestic dog	<i>Canis familiaris</i>	•	•	•	•
Equestrian		•		•	•
Hiker		•	•	•	•
Hikers with >2 dog				•	n/a
Human with dog				•	n/a
Staff				•	•
Vehicle		•	•	•	•
WPI crew		•	•	•	•
Ranger				•	n/a
<u>Livestock</u>					
Goats	(Goats)	•		•	•
Cattle	(Cattle)	•	•	•	
<u>Wildlife</u>					
Unknown	Unknown	•	•	•	•
Badger	<i>Taxidea taxus</i>		•		
Bird	(Bird)	•	•	•	•
Bat	(Bat)	•			
Black-tailed deer	<i>Odocoileus hemionus</i>	•	•	•	•
Black-tailed hare	<i>Lepus californicus</i>	•	•	•	•
Bobcat	<i>Lynx rufus</i>	•	•	•	•
Coyote	<i>Canis latrans</i>	•	•	•	•
Gray fox	<i>Urocyon cinereoargenteus</i>	•	•	•	•
Gray squirrel	<i>Sciurus griseus</i>	•	•	•	•
Opossum	<i>Didelphis virginiana</i>	•	•	•	•
Puma	<i>Puma concolor</i>	•	•	•	•
Raccoon	<i>Procyon lotor</i>	•	•	•	•
Striped skunk	<i>Mephitis mephitis</i>	•	•	•	•
Wild turkey	<i>Meleagris gallopavo</i>	•	•	•	•
Small rodent	(Small rodent)	•	•		•
Red fox	<i>Vulpes vulpes</i>			•	
Insect	(Insect)	•	•	•	
Lizard	(Lizard)	•			
Snake	(Snake)	•			

## **A review of trail-related fragmentation, unauthorized trails, and other aspects of recreation ecology in protected areas**

ELIZABETH LUCAS\*

*California Department of Fish and Wildlife, Region 5, Natural Community Conservation Planning Program, San Diego, CA 92123, USA (Retired)*

*\*Corresponding Author: libbylucas5@gmail.com*

Expanding levels of authorized and unauthorized non-consumptive recreation increasingly threaten sensitive biological resources in areas protected primarily or solely to conserve them. The majority of the documented effects on wildlife from non-consumptive recreation are negative. From a review of 84 papers in the recreation ecology literature about the effects of recreation on wildlife, the following topics emerged as warranting full consideration: trail-related internal fragmentation and expansion of the effect zone; the proliferation and use of unauthorized trails; disturbance thresholds; population-level effects; distinguishing facets of mountain biking; interpretation of observed behavioral responses by wildlife to recreation; magnitude and duration of responses; comparisons of effects among types of recreation and of results among studies; cumulative and synergistic effects; habituation; and the complexity of recreation ecology. Knowledge of these topics must inform efforts to cease the extant recreation-related exploitation of protected areas and to prevent it in the future. These efforts include: securing urgently needed perpetual monitoring, management, and enforcement commensurate with recreational pressure in dual-role protected areas to ensure the perpetuation of viable populations of focal sensitive species; preventing further use and proliferation of unauthorized trails; restoring areas damaged by inappropriate trails (i.e., unauthorized trails, unnecessarily redundant designated trails, and trails to be decommissioned); using science-based disturbance thresholds to develop management measures for recreation; using the best available science to guide all policy and decision-making about (1) the siting, design, and alignment of trails, and (2) the types, levels, and timing of recreation under consideration; and, planning separate protected areas and recreational areas in the future.

Key words: dual-role protected areas, effect zone, disturbance thresholds, internal fragmentation, mountain biking, non-consumptive recreation, perpetual monitoring/management/enforcement, recreation ecology, recreation-related disturbance to wildlife, unauthorized trails

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Conservation of habitats is a key strategy for conserving biodiversity worldwide (Pickering 2010a; Soulé and Noss 1998). The core function of many areas in California

protected for conservation is to ensure that the wildlife species living in them thrive in what is the nation's most biologically diverse state (CDFW 2015).<sup>1</sup> Areas protected for conservation (protected areas) include locally owned lands (e.g., county and city reserves), state-owned lands (e.g., ecological reserves, wildlife areas, state parks), federally owned lands (e.g., national wildlife refuges, wilderness areas), and privately owned lands (e.g., conservation easements, conservancy lands, mitigation banks and lands). Here, the focus is on protected areas conserved primarily or solely for the perpetuation of viable populations of sensitive species (i.e., species whose persistence is jeopardized).<sup>2</sup> These protected areas often serve a dual role of conserving biodiversity and providing nature-based recreational and educational opportunities for millions of people, despite the evidence that even non-consumptive recreation<sup>3</sup> may not be compatible with protected areas' core function (Reed and Merenlender 2008; Larson et al. 2016; Dertien et al. 2018; Reed et al. 2019).

Recreation ecology is the scientific study of the ecological effects of outdoor recreation and nature-based tourism activities and their effective management in natural or semi-natural environments (Monz et al. 2013; Gutzwiller et al. 2017).<sup>4</sup> Studies in recreation ecology have shown that the majority of documented responses of wildlife species to recreation are negative (Steven et al. 2011; Larson et al. 2016; Hennings 2017; Patten and Burger 2018). Recreation-related disturbance to wildlife is recognized as a threat to global biodiversity, and as having wide-ranging and, at times, profound implications for wildlife individuals, populations, and communities (Dertien et al. 2018). Documented negative effects include detrimental changes to behavior, reproduction, growth, immune system function, and levels of stress hormones, and ultimately the survival of individual animals and persistence of wildlife populations and communities.

In this review, several topics about recreation ecology became apparent as warranting full consideration.<sup>5</sup> These topics are (1) the major issues of trail-related fragmentation and

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1 Wildlife means all wild animals: insects, fish, amphibians, reptiles, birds, and mammals.

2 These areas include areas protected pursuant to Natural Community Conservation Plans and/or Habitat Conservation Plans (NCCPs/HCPs). An NCCP is a comprehensive, single- or multi-jurisdictional plan that provides for regional habitat and species conservation at an ecosystem level while allowing local land use authorities to better manage growth and development. Upon issuing an NCCP Permit, the California Department of Fish and Wildlife (CDFW) can authorize take of certain state listed species and other species of concern, subject to the terms of coverage under the NCCP (CDFW 2015). An HCP is the federal counterpart to an NCCP; the U.S. Fish and Wildlife Service prepares HCPs and issues HCP permits. The terms and conditions under which an NCCP/HCP's protected areas are conserved establish the types and levels of public access that are permitted (Burger 2012). The types and levels of public access vary among the NCCP/HCP protected areas from no access to guided-only access to open access.

3 In contrast to consumptive recreation (e.g., hunting, fishing), non-consumptive recreation is generally assumed not to directly extract a resource; it includes nature and wildlife viewing, beach-going, kayaking, hiking, biking, horseback riding, and wildlife photography (Reed and Merenlender 2008; CDFW 2016; Gutzwiller et al. 2017). From here forward, "recreation" means non-consumptive recreation, unless otherwise stated.

4 From here forward, "management" includes monitoring, management, and enforcement. The level of enforcement necessary depends on the level of continual management implemented; generally, the more the management, the less enforcement is necessary. In addition, monitoring and management encompass both the natural resources and human users of the protected areas.

5 The author read 71 articles and 13 reports about the recreation-related effects on wildlife; this paper does not cite all of them. All the articles are published in peer-reviewed journals. Some of the reports were peer reviewed and all were written by or contributed to by professionals in the fields of biology or ecology, though none of the reports were published in peer-reviewed journals to this author's knowledge (e.g., Burger 2012; Hennings 2017; Dertien et al. 2018; Reed et al. 2019). And, the totals exclude documents that are not explicitly about recreation-related effects on wildlife (e.g., Taff et al. 2019) and all newspaper articles.

expansion of the effect zone, unauthorized trail creation and use,<sup>6</sup> disturbance thresholds, population-level effects, and distinguishing facets of mountain biking, and (2) the following aspects of recreation ecology: the interpretation of observed behavioral responses by wildlife to recreation, magnitude and duration of responses, comparisons of effects among types of recreation and of results among studies, cumulative and synergistic effects, habituation, and the complexity of recreation ecology.

This paper discusses the issues identified above to inform efforts to cease the extant recreation-related exploitation of protected areas and to prevent it in the future. These efforts include: securing urgently needed perpetual management of recreation commensurate with recreational pressure to ensure the perpetuation of viable populations of focal sensitive species<sup>7</sup> as intended upon establishment of the protected areas; preventing further use and proliferation of unauthorized trails; restoring areas damaged by inappropriate trails (i.e., unauthorized trails, unnecessarily redundant designated trails, and trails to be decommissioned); using science-based disturbance thresholds; using the best available science to guide all policy and decision-making about the siting, design, and alignment of trails, and about the types, levels, and timing of recreation under consideration; and, planning separate protected areas and recreational areas in the future. This paper discusses the above-listed aspects of recreation ecology for consideration in designing field studies and while reviewing recreation ecology literature.

### **Trail-related disturbance: fragmentation, edge effects, and expansion of the effect zone**

*External fragmentation.*—There is much peer-reviewed literature on the ecological effects of fragmentation, a process by which once-contiguous areas of habitat are physically separated by human disturbance creating a network of isolated habitat patches (Soulé et al. 1988; Ballantyne et al. 2014; Vickers et al. 2015; Cheptou et al. 2017). Most fragmentation research worldwide has concentrated on progressive losses of natural habitat through removal of vegetation as a result of development, agriculture, and resource extraction. Physical fragmentation, in conjunction with other related factors (e.g., duration of isolation of habitat fragments, low vagility of species, loss of genetic diversity), causes the isolated areas of habitat to experience a decay of species diversity over time due to local extinctions (Soulé et al. 1988). Consequently, fragmentation is a major threat to biodiversity (Cheptou et al. 2017). This fragmentation is considered external to the protected areas within a landscape, though it influences the viability of protected areas with respect to wildlife conservation.

*Internal fragmentation.*—Recreational trails themselves can fragment habitat, thereby causing fragmentation that is internal to the areas they traverse (Pickering 2010a; Leung et al. 2011; Burgin and Hardiman 2012; Pickering and Norman 2017). Because of their linear nature, trails can have a greater negative effect than if the affected terrain were consolidated in a more compact form (Pickering 2010a). Complex networks of trails within protected areas

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6 The literature refers to illegally created trails and constructed trail features variously as unauthorized, informal, social, unofficial, off-trail, visitor-created, user-created, and demand trails. “Unauthorized” is the term of choice here because it is the only term among these that clearly denotes the illegality of the creation and use of such trails and features.

7 Focal species are organisms whose requirements for survival represent factors important to maintaining ecologically healthy conditions; types of focal species include keystone species, umbrella species, flagship species, and indicator species. Focal species are identified for the purpose of guiding the planning and management of protected areas in a tractable way (Soulé and Noss 1998, Marcot and Flather 2007). Here, the term “focal species” is intended to include those species encompassed by the guild surrogate approach of conservation; this approach entails one member or a subset of members serving as a surrogate for other members of the guild (Marcot and Flather 2007).

can cumulatively affect nearly as much area as the above-mentioned external fragmentation (Ballantyne et al. 2014). Substantial evidence exists that trails may act as barriers to the movement of animals due to behavioral avoidance, the presence of a physical barrier, or development of a home range along the physical barrier (Burgin and Hardiman 2012). Trail density is a main factor influencing how wildlife respond to trail users and the ability of wildlife to disperse or reach seasonally important habitats such as breeding grounds (D'Acunto et al. 2018). Particularly when resulting from unauthorized trails or poorly sited and/or designed official trails, internal fragmentation can compound the negative effects of the external fragmentation in the surrounding landscape. The arterial spread of multiple cleared areas for trails within protected areas may cause losses of plant communities and ultimately result in long-term degradation of protected areas across large areas (Ballantyne et al. 2014).

**Effects of trail presence on wildlife.**—A likely consequence of internal fragmentation within protected areas is that the mere presence of trails, even in the absence of humans, can compromise protected areas' ability to sustain sensitive species (Pickering and Norman 2017; Baker and Leberg 2018). This is partly due to edge effects in the area of transition between two contrasting habitats, where resulting changes can occur in species abundance, community structure, and/or predation and parasitism (Zurita et al. 2012). Edge effects are major drivers of change in many fragmented landscapes (Laurance et al. 2007) and factor into the observations that internal fragmentation can restrict movement of some native animals and plants among habitat fragments and enhance the movement of invasive species along the trails (Barros and Pickering 2017). Baker and Leberg (2018) found that the presence alone of roads and trails, and not necessarily how often humans use them, had a significant negative effect on the occupancy of most of the 11 mammalian carnivore species they studied. Trails also potentially expose native animals to predators, including feral species such as the red fox (*Vulpes vulpes*), that penetrate natural areas by moving along the trails (Burgin and Hardiman 2012): a study on the effects of mountain biking on golden-cheeked warblers (*Dendroica chrysoparia*) found that the indirect effects from fragmentation and alteration of habitats from mountain biking trails may reduce the quality of the warblers' nesting habitat by increasing the vulnerability of warbler nests to predation by rat snakes (*Elaphe obsoleta*) and other edge-adapted predators (Davis et al. 2010). Edge effects associated with trails are known to affect other avian species similarly and to reduce the local abundance and nesting frequency of certain avian species, increase the incidence of nest parasitism by cowbirds, and affect avian vocalizations (Hennings 2017). The penetration of edge effects into the areas adjacent to trails is an aspect of internal fragmentation that underscores the ecological cost of unauthorized trails (Pickering and Norman 2017).

**Trails expand the zone of effect.**—Another notable consequence of trails is the expansion of the zone of effect of recreational disturbance to wildlife as habitats become more open, as occurs from the proliferation of unauthorized trails (Reed et al. 2019). In this context, "effect zones" are areas within which wildlife is disturbed by recreational activities on trails; effect zones encompass and extend beyond the area influenced by edge effects. The expanse of effect zones likely varies depending on the types and intensities of recreation and therefore may not be consistent across a trail network (Reed et al. 2019). Particularly in urbanized areas where protected areas are already highly confined in the surrounding urban matrix, the expansion of the effect zones further dissects and internally fragments what are already essentially habitat 'islands' (Ballantyne et al. 2014; Pickering and Norman 2017).

The expansion of effect zones occurs in all protected areas with widespread trails irrespective of the sizes of the protected areas. For small protected areas (~300 ha) with dense trail networks, an effect zone of several hundred meters on either side of the trails can encompass a substantial proportion of the protected areas (Reed et al. 2019). In this way, effect zones reduce the proportion of a protected area that is suitable for various wildlife species (Reed et al. 2019), and can result in no contiguous areas across a protected area free from recreation-related disturbance to wildlife (Dertien et al. 2018).

The higher the level of recreation in protected areas, the greater the potential there is for the effects of trails and their use to extend beyond habitat loss and individual-level effects (behavioral and physiological) on wildlife into population- and community-level effects, including depletion of floral and faunal populations, alteration of trophic and community structures, and reduction of biodiversity (CDFW 2015). If habitat is available, wildlife may move to areas farther from trails, areas beyond the effect zone, to avoid recreation-related disturbance (Reed et al. 2019). However, the greater the proportion of a protected area occupied by effect zones, the fewer options there are for wildlife to move to areas outside the effect zones.

### **Unauthorized trails and technical trail features**

*General.*—The implications to wildlife conservation of the disturbance to wildlife from trail-related fragmentation and expansion of effect zones are particularly grave with respect to unauthorized trails and recreational activities. The creation and use of unauthorized trails and technical trail features (TTFs) are commonplace and present concerns about the sustainability of biological resources in protected areas worldwide (Marion and Wimpey 2007; Newsome and Davies 2009; Ballantyne et al. 2014; Havlick et al. 2016; Barros and Pickering 2017).<sup>8</sup> Though most unauthorized trails and TTFs are readily visible and accessible, they are not officially planned or designed, approved for construction, managed, or part of a formally designated trail network (Davies and Newsome 2009; Leung et al. 2011; Hennings 2017). All user groups tend to create and use unauthorized trails, and there are several motivations for doing so, such as wanting access to trails closer to home or to engage in off-trail activities (Hennings 2017).

Though other recreationists venture off of designated trails, mountain bikers increasingly create unauthorized trails as they seek more challenging, wider-ranging, or free-riding opportunities (Havlick et al. 2016), or want a shortcut to reach specific destinations or to connect existing trails (Davies and Newsome 2009). If a trail is not sited in a place where bikers want to go, the off-trailing that results eventually forms trails (Davies and Newsome 2009).

Unauthorized trails expand the negative effects of human recreation on the flora and fauna of any protected area (Dertien et al. 2018). Similar to the above-discussed problems associated with internal fragmentation, unauthorized trails and recreational activities can negate the ecological benefits of both well-planned designated trails/trail networks and of prohibitions on access and activity (e.g., avoidance of breeding areas and seasonal access restrictions). The proliferation of unauthorized trails is often more responsible for trail-based fragmentation than formally designated trails (Ballantyne et al. 2014).

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<sup>8</sup> TTFs are created on mountain biking trails to increase the challenge of the ride. Examples of TTFs are jumps, ditches, mounds, bridges, ramps, ladders, drop offs, see saws, and 'skinnies' (i.e., narrow features that can be traversed) (Davies and Newsome 2009; Pickering et al. 2010c; Quinn and Chernoff 2010; Ballantyne et al. 2014; Havlick et al. 2016; Hennings 2017; Pickering and Norman 2017).



Even where unauthorized trails occupy a relatively small proportion of a landscape, they can be quite detrimental if in vital habitat; sensitive species whose territories or home ranges include the affected area(s) may be prevented via displacement or loss of habitat connectivity from accessing limited and essential resources (Gutzwiller et al. 2017). Wildlife can be more disturbed by off-trail than on-trail recreationists. For example, Taylor and Knight (2003) compared how mule deer (*Odocoileus hemionus*) respond to hikers and bikers using designated trails and one randomly chosen off-trail route. The deer exhibited a 70% probability of flushing from on-trail recreationists within 100 m from designated trails, whereas they exhibited a 96% probability of flushing within 100 m of recreationists located off trails, and their probability of flushing did not drop to 70% until the distance from the recreationists reached 390 m.

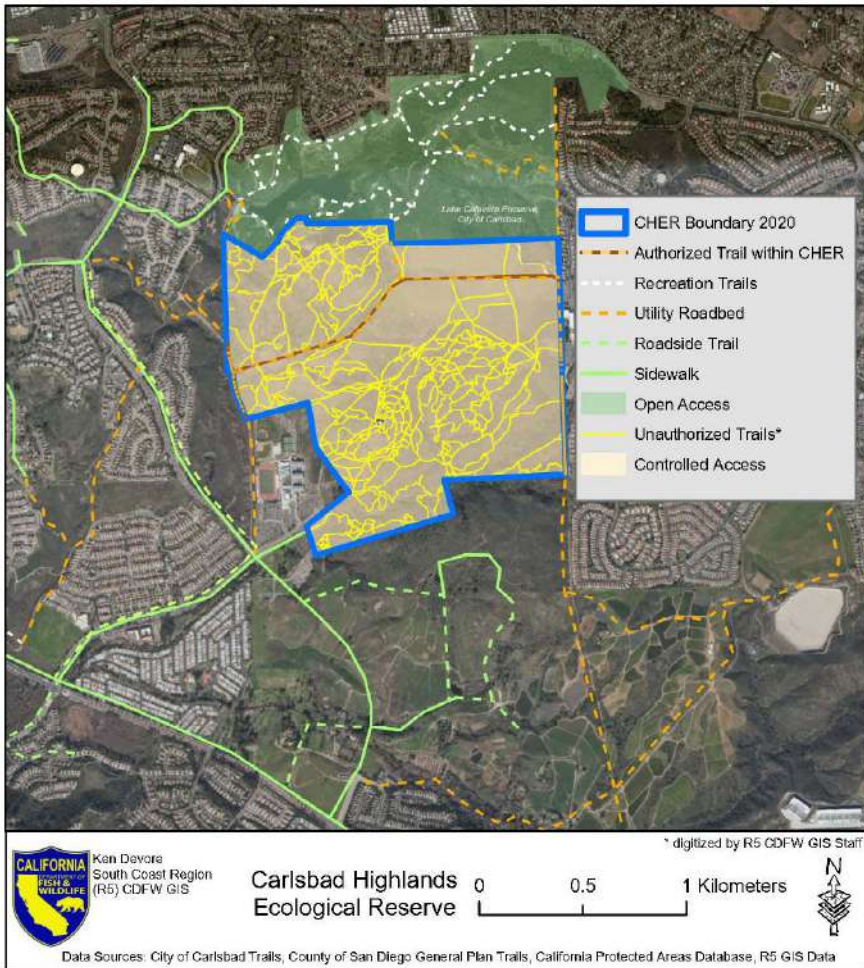
*Examples.*—Examples of protected areas affected by unauthorized trails include: 19 Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP; see footnote #2) protected areas in San Diego County, California where unauthorized trails comprise a mean of 45% (range: 8–85%) of the 1,206 km of trails mapped (Reed et al. 2014); an 829-ha area of the endangered Tall Open Blackbutt Forest in southeast Queensland, Australia, where 57% (26.5 km) of the 46.1 km of recreational trails was unauthorized when mapped in 2013 (Ballantyne et al. 2014); and, a 237-ha protected area in Argentina where 94% of the 19 km of trails found was unauthorized, resulting in landscape-level fragmentation and loss of vegetation (Barros and Pickering 2017). Another example of a protected area affected by unauthorized trails is the 191-ha Carlsbad Highlands Ecological Reserve in San Diego County. Though mountain biking is prohibited in this reserve, in addition to the 4 km of legal hiking trails in the reserve are also 27.4 km of unauthorized mountain biking trails and TTFs (E. Pert, South Coast Region, Regional Manager, California Department of Fish and Wildlife [CDFW], personal communication, 2019; Figure 1). This ecological reserve, so designated in 2000, comprises a critical component of an NCCP/HCP protected area and supports coastal sage scrub (a sensitive plant community), grasslands, thread-leaved brodiaea (*Brodiaea filifolia*, listed as threatened and endangered under the Federal and California endangered species acts, respectively), and several sensitive wildlife species: the federally threatened coastal California gnatcatcher (*Polioptila californica*), sharp-shinned hawk (*Accipiter striatus*), golden eagle (*Aquila chrysaetos*), white-tailed kite (*Elanus leucurus*), turkey vulture (*Cathartes aura*), and grasshopper sparrow (*Ammodramus savannarum*).<sup>9</sup>

*Managing unauthorized trail creation and use.*—Managing the rapid proliferation of unauthorized mountain biking trails and TTFs and their use is challenging. Even if only a small proportion of bikers is involved, the resulting vandalism can have serious ecological consequences as is well reflected in the statement, “[g]enerally when you ask people to stay out of the area no matter what the reason is, 80-90% obey you, [b]ut if you get 10% who don’t obey you, you haven’t done any good” (Bill Andree, retired district wildlife manager of Colorado Parks and Wildlife; Peterson 2019).

In the aforementioned Carlsbad Highlands Ecological Reserve, enforcement and education are necessary to substantially reduce the illegal riding, but the bikers monitor

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<sup>9</sup> Of CDFW’s 136 ecological reserves (ER) statewide, biking is allowed on eight. About ERs, Title 14, California Code of Regulations §630(a) states, “All ecological reserves are maintained for the primary purpose of developing a statewide program for protection of rare, threatened, or endangered native plants, wildlife, aquatic organisms, and specialized terrestrial or aquatic habitat types. Visitor uses are dependent upon the provisions of applicable laws and upon a determination by the [Fish and Game] commission that opening an area to such visitor use is compatible with the purposes of the property.”



**Figure 1.** Carlsbad Highlands Ecological Reserve, Carlsbad, California. The yellow lines represent the unauthorized trails. Their associated effect zones occupy most, if not all of, the Ecological Reserve. (Credit: Ken Devore, South Coast Region (R5), GIS, CDFW 2017).

enforcement activity and recommence riding in the ecological reserve when enforcement officers leave (E. Pert, CDFW, personal communication, 2019). A similar protected area is the 350-ha Del Mar Mesa Preserve (Preserve) in the City of San Diego; the Preserve supports rare and endangered species such as Del Mar Manzanita (*Arctostaphylos glandulosa* ssp. *crassifolia*), Orcutt's brodiaea (*Brodiaea orcutti*), San Diego button celery (*Eryngium aristulatum* var. *parishii*), San Diego mesa mint (*Pogogyne abramsii*), San Diego fairy shrimp (*Branchinecta sandiegonensis*), and the California gnatcatcher, and was the subject of a study the City conducted to determine whether enforcement by CDFW Wildlife Officers (wardens) is an effective method to curb unauthorized trail uses (SANDAG 2015; Greer et al. 2017). Of the 32.22 km mapped trails on a 257-ha portion of this Preserve, 21.98 km are considered unauthorized (Reed et al. 2014). Prior to the study, City Park Rangers had

conducted regular educational efforts in the field an average of 3–4 times monthly over a 17-month period. Despite the Rangers' efforts, non-compliance became the social norm as more users followed expanding numbers of unauthorized trails (Greer et al. 2017). The subsequent period of the CDFW Wildlife Officers' enforcement comprised 810 hours during a 12-week period with an unpredictable schedule. Prior to enforcement activities, the majority (78.7%) of the use within the study area was illegal, and over 85.5% of the illegal use was mountain biking. Illegal mountain biking decreased quickly during the enforcement period by 66.0% over the study period and stayed low during the 43-day post-enforcement period, while legal mountain biking remained the same. Other illegal use also decreased significantly, while other legal uses doubled (Greer et al. 2017). Greer et al. (2017) cite decades of research indicating that a combination of soft (i.e., education) and hard (e.g., warnings, citations, arrests, confiscation of bikes) enforcement is the most effective approach to promoting compliance. They assert that education becomes less effective in areas with chronic unauthorized trail creation and use.

Overall conclusions from Greer et al.'s (2017) study follow: (1) soft enforcement aimed at public education and redirecting social norms was not sufficient to curb unauthorized trail use in the Preserve; (2) open space enforcement by CDFW Wildlife Officers was determined to be effective in reducing unauthorized use in the Preserve; (3) the threat of sanctions (hard enforcement) has a more general utility and effectiveness in curbing non-compliant behavior than outreach to promote "awareness-of-consequence" of user actions (soft enforcement). The authors also concluded that social media has great potential to engage and educate the public on environmental issues, and that its use in combination with community policing can be a powerful tool to: redirect user attitude and subsequent behavior through peer-to-peer education about environmental impacts; answer questions regarding authorized uses; and, warn users of potential sanctions for non-compliance. They recommend the implementation of a social media component prior to and during enforcement efforts to help educate recreationists and reduce misinformation and recreationists' distrust of managers and enforcement personnel (Greer et al. 2017).

*Paucity of information available.*—Despite the global proliferation and use of unauthorized trails and TTFs and their far-reaching effects on wildlife in protected areas, there is a paucity of information of any depth available on such effects. The impacts of unauthorized trails and TTFs have been rarely documented (Marion and Wimpey 2007; Davies and Newsome 2009). A comprehensive literature search prior to 2010 produced only eight studies documenting the effects of unauthorized trails (Pickering et al. 2010c). Since then, additional studies have assessed the effects on vegetation from unauthorized trails, with little elucidation about their effects on wildlife. The proliferation, use, and wildlife-related effects of unauthorized trails remain understudied and insufficiently addressed. For protected areas where the creation and use of unauthorized trails and TTFs are prevalent, it is infeasible to fully assess the recreation-related effects on wildlife without including these activities and their effects. Yet, these effects have a great potential to impair the ability of protected areas to meet their conservation objectives.

## **Disturbance thresholds**

Disturbance thresholds are predetermined levels of various measurable indicators above or below (depending on the indicator) which wildlife is disturbed (Hennings 2017).

These thresholds may be used to establish management measures such as minimum widths of spatial buffers between recreational trails and wildlife. Exceedance of a threshold may trigger the implementation of further management measures (Hennings 2017). Examples of disturbance thresholds are distance between people and wildlife or between trails and nesting sites (i.e., the distance within which wildlife species avoid people or trails), density of active trails above which wildlife alters its use of habitat, number of recreationists per day over which wildlife abundance decreases, duration of recreation, and number of recreational events per unit time (Hennings 2017; Dertien et al. 2018).

Thresholds should be set at levels equal to or more protective of predetermined levels of disturbance, and should be responsive to trends in changing conditions as identified by monitoring (Hennings 2017). Data from studies of recreational activities can be used to estimate quantitative thresholds of disturbance to wildlife (Dertien et al. 2018); however, determining these thresholds requires very specific empirical data (Rodríguez-Prieto et al. 2014).

While determining and using disturbance thresholds would be ideal for managers to optimize management decisions (Rodríguez-Prieto et al. 2014), they are difficult to determine for broad application. For example, thresholds established for distance to trail are not necessarily adequately protective of the focal species under all conditions in which they occur; a general rule of minimum thresholds for distance to trail cannot be established for some species, as individual variability within species can be high and can differ among populations, types of topography, and frequencies and types of human intrusion (González et al. 2006). As a result, the literature about recreation-related disturbance to wildlife provides limited information about quantitative thresholds for distance to trail (Dertien et al. 2018). Though their sample sizes (i.e., number of articles reviewed with such information) are accordingly small, Dertien et al. (2018) found the following examples of such thresholds: wading birds and passerines were generally affected at distances less than 100 m; larger-bodied species such as hawks and eagles had threshold effect distances greater than 400 m; small rodent species avoided areas within 50-100 m of trails or people; and some carnivores and ungulates had minimum effect distances up to 350-1000 m from trails and people.

As another example of a spatial buffer, Dertien et al. (2018) recommend a 200-m minimum buffer for ungulates; however, this would be insufficient for the circumstances of Taylor and Knight's (2003) study in which they found that mule deer showed a 96% probability of flushing within 100 m of recreationists located off trails, and the probability of their flushing did not drop to 70% until perpendicular distance reached 390 m. Two additional factors that influence the determination of spatial buffers are the density of the trail networks and the above-discussed effect zones. The smaller a protected area is and the denser its trail networks are, the greater the proportion of the protected area is occupied by effect zones, and the less likely it is that spatial buffers will protect the focal species from recreational disturbance (Wilcove et al. 1986; Ballantyne et al. 2014).

Land managers should consider both trail density and the level of human recreation before deciding on disturbance thresholds, since thresholds that work at lower levels of human activity may be ineffective when activity levels increase (D'Acunto et al. 2018). D'Acunto et al. (2018) simulated the success of trail closure strategies on reducing disturbance from Off Road Vehicles and pedestrians to nesting golden eagles during laying and incubation, focusing on eagle flushing behavior from the nest and alteration of foraging flight. They found that, for current levels of human recreation, the restrictive buffer (i.e. all trails closed

within the buffer) was best at reducing flushing of incubating eagles, while closing all but the popular trails was best for foraging eagles. When the simulated human recreation was increased, trail density was the main factor influencing eagle flushing frequency.

Hennings (2017) reports the following thresholds for levels of human recreation (i.e., number of users) from four studies: for guanacos (*Lama guanicoe*), about 250 visitors per day, above which the number of birds observed declined; for sanderlings (*Calidris alba*), 20 visitors per day; for songbirds, eight out of 13 species showed thresholds ranging from 8-37 visitors per ha; and, for Mexican spotted owls (*Strix occidentalis lucida*), around 50 hikers per day. Regardless of any threshold effects, the majority of the research indicates that more visitors will generally cause more wildlife effects (Hennings 2017). However, since recreational impacts vary nonlinearly with use in a variety of ecosystems, a small number of visitors can have a disproportionate impact on sensitive species (Reed and Mendlender 2008).

### Other aspects of recreation ecology to consider

*Interpretation of observed behavioral responses.*—It is possible to misconstrue the reasons for and implications of observed responses by wildlife to recreational activity. Traditionally and intuitively, species or individuals showing strong negative responses (e.g., readily flee or avoid) to human disturbance are those assumed to most need protection from disturbance. However, species with little suitable habitat available nearby cannot show marked avoidance of disturbance even if the fitness costs of the disturbance are high (e.g., reduction of survival or reproductive success; Gill et al. 2001). Conversely, species with many nearby alternative sites to move to are likely to move away from disturbance even if the fitness costs of the disturbance are low (Gill et al. 2001). It should not be assumed that the most responsive animals are the most vulnerable (Beale and Monaghan 2004). For example, in a controlled study of the behavioral responses of a shorebird (ruddy turnstone, *Arenia interpres*) to human disturbance (an approaching observer), Beale and Monaghan (2004) found that birds in better condition (i.e., supplemented with food) had longer flight initiation distances (i.e., flushed sooner) from the disturbance and searched for predators more frequently than control birds (i.e., not supplemented with food).<sup>10</sup> That is, birds responding most were actually the least likely to suffer any fitness consequences associated with the human presence; this is opposite from the response generally expected when behavior is used as an index of disturbance effects. Birds that had the most to lose by flushing, or otherwise changing their behavior in a manner that reduced feeding time, showed the least behavioral response; this could be interpreted incorrectly as meaning that these birds were not disturbed. Gill et al. (2001) assert that the absence of an obvious behavioral response does not rule out a population-level effect. In the same vein, it may be that species occurring in protected areas that are remnant fragments within urban landscapes are forced to utilize all components of the fragments, irrespective of their land-use intensity and land cover. This may occur if animals have nowhere else to go, and may be an explanation for instances when total relative abundance of birds is greater in urban and suburban reserves than in exurban reserves (Markovchick-Nicholls et al. 2008).

In addition to the reasons Gill et al. (2001) provide for an absence of detected effects, other possible reasons for finding no recreation-related effects include that there

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<sup>10</sup> Flight initiation distance is the distance from an approaching threat (e.g., recreationist) at which an animal begins to move away to escape from the threat.

may be a negative effect but it is not detected due to methodological issues. For example, the response variable examined (e.g., behavior versus physiology) and/or the number of replicates used compared to the amount of variation in the traits measured may not reveal the actual response of the species studied or the associated longer-term population-level effects (Steven et al. 2011). Furthermore, some studies may not include sufficiently high levels of human activity to detect responses from species that can tolerate lower levels of disturbance (Reed et al. 2019).

*Threatened, endangered, and sensitive species.*—Current research of recreation-related effects on wildlife does not include many species of urgent conservation concern (Larson et al. 2016). As many rare and isolated species tend to be specialists, anthropogenic activities could have a greater detrimental effect on the distribution, breeding success, and survival of individuals of these species (Beale and Monaghan 2004b; Bennett et al. 2013) than found in studies involving less sensitive species. Studies do not always reveal the strongest effects because the most disturbance-sensitive species are naturally rare in number or are already gone from disturbed sites (Hennings 2017). While recreation may not be the primary reason for the sensitive status of such species, it is a threat worth understanding for types of recreation that occur in the protected areas designated to conserve them (Larson et al. 2016).

*Magnitude and duration of wildlife responses to recreation.*—It is known that the nature (e.g., behavioral, physiological), magnitude, and duration of recreation-related disturbance to wildlife depend on a variety of factors, including, but not limited to, frequency and type of recreation, distribution of recreational use, season(s) of use, and environmental conditions (Marzano and Dandy 2012). Evaluating the effectiveness of measures to manage recreation can be complicated by the intensity of recreational use of a protected area because levels of use influence the magnitude of recreation-related effects on wildlife (Reed and Merenlender 2011). But studies do not always quantify the levels of recreational uses. Likewise, research seldom provides insight to the duration of wildlife species' response (e.g., nest abandonment, interruption of foraging/hunting, breeding, fleeing) to human disturbance (Marzano and Dandy 2012; Burger 2012; Larsen et al. 2016) or degree of response (e.g., how far wildlife moves away from human disturbance at a greater energetic cost and resulting in less availability of habitat). The same is true for the spatial scale at which wildlife response occurs (Burger 2012).

*Generalized comparisons of effects among types of recreation.*—It is clear from the literature that recreation in protected areas, particularly in more urbanized areas, can negatively affect wildlife (Larsen et al. 2016). However, it is difficult to make defensible generalized comparisons of the effects on wildlife among different types of recreation, partly because of the diversity of recreational activities, study methodologies, and observed responses (Monz et al. 2013). A comparison of results among similar studies indicates that sweeping conclusions about the effects of urbanization and human activity on wildlife need to be made with caution and are likely to be species-specific (Markovchick-Nicholls et al. 2008). For example, applying this caution to one species, the U.S. Fish and Wildlife Service (2000) concludes that attempts to ascribe relative importance, distinguish among, or generalize the effects of different human activities on bighorn sheep (*Ovis canadensis*) behavior are not supportable, given the range of potential reactions reported in the literature and the different variables impinging on given situations. Therefore, generalized comparisons of the effects on wildlife among different types of recreation are ill advised. The differences among types of recreation in their effects on wildlife are less important than the negative association for wildlife of human presence, irrespective of type of recreation (Patten and Burger 2018).

Despite the difficulty of making well-founded comparisons of the effects on wildlife among different types of recreation, comparisons are made. Among the types of recreation examined in the literature, the ecological effects of hiking and biking are most often compared. For studies done in the United States, this reflects the 22% increase to 8.3 million from 2006 to 2015 in mountain bikers, and the 24% increase to 37.2 million hikers during the same time period (Hennings 2017). And, notwithstanding the foregoing caveat about generalized comparisons, Hennings (2017) underscores that photographers, people with small children, bird watchers, and people engaging in loud conversations may be especially detrimental to bird communities because they are unpredictable and generally alarming. Photographers and wildlife watchers tend to stop, look directly at wildlife, and even follow them around, triggering stronger antipredator responses than people who simply pass by; photographers also tend to seek out rare species and look for nests. Also, curious, excited children tend to run around and shout in an unpredictable fashion (Marzano and Dandy 2012; Hennings 2017).

*An absence of differences among effects.*—The absence of differences among recreational activities' effects on wildlife does not equate to no effects. There can be similar levels of both benign or significant effects. For instance, in a study of bison (*Bison bison*) and pronghorn (*Antilocapra americana*), the authors found little difference in wildlife response (i.e., alert distance, flight initiation distance, or distance moved)<sup>11</sup> to hikers versus mountain bikers, but both species exhibited a 70% probability of flushing when within 100 m from trails with recreationists present (Taylor and Knight 2003).

*Cumulative and synergistic negative effects.*—The negative effects of recreation on wildlife compound, and may also act synergistically with, those from other influences (Larson et al. 2016; Reed et al. 2019). The cumulative negative effects of all anthropogenic influences on wildlife complicate efforts to minimize the effects and assess their population-level consequences (Pirotta et al. 2018). However, recreation ecology studies typically do not factor in other anthropogenic influences to which wildlife in protected areas are exposed (Pickering et al. 2010c; Erb et al. 2012; Messenger et al. 2014; Reed et al. 2019). Other anthropogenic influences include climate change and its associated effects on natural disasters; fires and other natural or human-caused disasters; consumptive recreation; non-recreational human activity such as habitat loss or alteration, the associated lack of connectivity, and the resulting loss of genetic diversity; poor air and/or water quality; invasive species; roads; vehicles; artificial light; prey declines; reverse zoonoses; drones; and noise (e.g., from vehicles, planes, ships, and boats). Recreation-related cumulative effects may be important if, for instance, the densities of different types of recreationists influence predator use of sites more than does the density of any one type of recreationist alone (Gutzwiller et al. 2017).

*Wildlife habituation to human activity.*—Habituation is a form of tolerance in which, as the result of a lack of negative consequences, there is a waning of response to a repeated, neutral stimulus (Whittaker and Knight 1998; Pauli et al. 2017). Habituation allows wildlife to use their energy for normal fitness-enhancing behaviors such as resting, foraging, and mating instead of fleeing when confronted with human activities that result in neutral outcomes (Whittaker and Knight 1998; George and Crooks 2006; Reilly et al. 2017). Habituation is

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<sup>11</sup> Alert distance is the distance from a stimulus at which an animal initiates vigilance behavior (Guay et al. 2016 in Reed et al. 2019); more specifically in this context, it is the distance between a recreationist and an animal when the animal first becomes visibly alert to the recreationist. Distance moved is the distance an animal travels from its initial position until it stops (Taylor and Knight 2003).

an apt description for crows (*Corvus* spp.) ignoring a scarecrow, or a red fox ignoring the human activity in a suburban area (Whittaker and Knight 1998). Citing several authors' work, Martínez-Abraín et al. (2008) identify level and frequency of disturbance, species, location, size and diet of species, and age of individual animals as factors that affect the degree of wildlife habituation to human disturbance.

The ability to habituate to predictable and recurrent human use of recreational trails may be an important behavioral adaptation for wildlife (González et al. 2006; Martínez-Abraín et al. 2008). However, habituated urban wildlife might be less likely to avoid contact with humans, which may increase the probability of human-wildlife conflicts and of attraction to anthropogenic food sources; both circumstances are considered problematic in many urban areas (Whittaker and Knight 1998; George and Crooks 2006). Wildlife habituation to humans may also increase wildlife aggression toward humans, or render wildlife more vulnerable to predators, hunters, poaching, or roadkill (Whittaker and Knight 1998; George and Crooks 2006; Marzano and Dandy 2012). Habituation of adult individuals may be associated with negative consequences for their offspring since habituation of adult animals does not translate to immediate habituation of juveniles (Reilly et al. 2017).

True habituation is not easily measured, and what appears to be habituation is often not (Hennings 2017). Apparent habituation is not a true measure of whether people are disturbing wildlife (Hennings 2017). Wildlife can experience significant stress without fleeing, and when this is misconstrued as habituation, disturbance effects on wildlife are underestimated (Hennings 2017). Care must be taken to avoid attributing a lack of observable response by wildlife to human presence as habituation (Beale and Monaghan 2004). Wildlife that seem not to avoid recreational disturbance may experience stress or be unable to leave a site if, for example, there is no suitable habitat nearby (Gill et al. 2001; Beale and Monaghan 2004; Markovchick-Nicholls et al. 2008).

While habituation to human disturbance could result in development of tolerance within a population (Pauli et al. 2017), Bötsch et al. (2018) infer from their findings on the recreation-related disturbance to birds in forests where recreation has occurred for decades that habituation to humans has not outweighed the effects of the disturbance. A long-lived species with low recruitment, such as the golden eagle, may be unable to experience individual learning or population-level evolutionary adaptation at a rate sufficient to compensate for a rapidly shifting anthropogenic landscape (Pauli et al. 2017).<sup>12</sup>

In a study subjecting captive female elk to four types of recreational disturbances (all-terrain vehicles riding, mountain biking, hiking, and horseback riding) over a two-year period, the elk showed no evidence of habituation to mountain biking. Similarly, elk travel time in response to hiking was generally above that of control periods, suggesting elk also did not habituate to hiking disturbance (Naylor et al. 2009).

In a study of how bison, mule deer, and pronghorn responded to hikers and bikers on designated recreational trails, Taylor and Knight (2003) found little evidence of habituation to recreationists among the species at the time of the study (summers of two consecutive years). In fact, the pronghorn at the study site did not habituate to largely predictable recreational use over a three-year period following the opening of trails at the site, and used areas that were significantly farther from trails than they had prior to the start of recreational use.

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<sup>12</sup> Evolutionary adaptation is the hereditary alteration or adjustment in structure or habits, the process by which a species or individual improves its ability to survive and pass on its genes in relationship to the environment (Ha and Campion 2019); unlike habituation, evolutionary adaptation does not result from learning during an individual's lifetime.



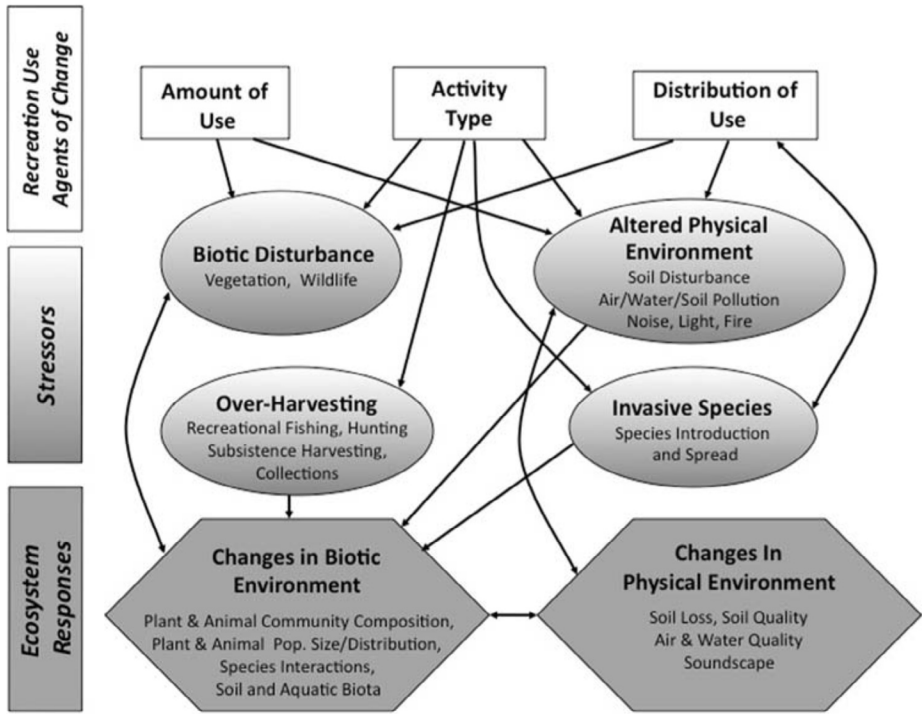
Hennings (2017) asserts that wildlife do not appear to habituate to the presence of dogs; impacts potentially linger after dogs are gone because the scent of dogs repels wildlife. It may be too that wildlife do not habituate to dogs (particularly off-leash dogs) because wildlife perceive dogs as predators and because they are unpredictable (Hennings 2016). Dog-specific disturbance has been studied for birds, with no evidence of habituation even with leashed dogs and even where dog-walking was frequent; the disturbance was much weaker for people without dogs (Hennings 2016).

*The challenge of research.*—Recreation ecology, similar to other fields of ecology, faces challenges in conducting statistically valid research (Quinn and Chernoff 2010). The degree to which and how the biotic and abiotic resources present in any one location respond directly or indirectly to recreational activities depends on many variables, some of which may be confounding (Figure 2, Table 1). Measuring the effects of human activity on wildlife is difficult because of the variability in the underlying spatial, diurnal, seasonal, and even the type of, indices being measured (Burger 2012). Recreation-related effects on wildlife vary among species (Larson et al. 2016) as different wildlife species respond differentially to visual, auditory, olfactory, and tactile stimuli (Hennings 2017). Wildlife responses to recreationists are likely influenced by a suite of variables that may differ in each field setting (Steidl and Anthony 1996; Taylor and Knight 2003), including level of human presence/activity that evokes a response as well as feedbacks and interactions with other factors (e.g., edge effects, availability of cover, exposure to disturbance, or time since fire; Patten and Burger 2018). Study methodology (i.e., design, sampling, data collection, and data analysis) itself encompasses many variables that dictate how other variables will influence the study outcomes. Even if methodology is consistent between/among two or more studies, other variables can result in different study results (Taylor and Knight 2003). Methodological issues may limit the inferences that can be made from the results (Pickering et al. 2010c).

Study design and statistical analyses can utilize methods to control for the effects of confounding variables (e.g., by using covariates). Statistical analyses can be used to examine alternative use-impact or use-response relationships between recreational activity and wildlife responses to assess the effects of recreational activity relative to other known drivers (e.g., habitat fragmentation, invasive species) of species occupancy, distribution, physiology, reproduction and survival (Monz et al. 2013; Reed et al. 2014).

*Differences among study results.*—Differences among studies' results can be due more to differences in variables not accounted for (e.g., space, diet, competition; Markovchick-Nicholls et al. 2008), study design, and/or analytical methodologies than to actual differences among species' responses to recreational disturbance. As to methodology, for instance, some studies may not include sufficiently high levels of human activity to detect responses from species that can tolerate lower levels of disturbance (Reed et al. 2019).

Reilly et al.'s (2017) study using camera trap data to quantify how hiking, mountain biking, horseback riding, and dog-walking affect habitat use/occupancy and diel shifts in activity patterns of ten mammalian species is illustrative for this discussion because some of its results differ markedly from those of other studies. For example, the authors found no negative association between recreation and habitat use by bobcats (*Lynx rufus*) and coyotes (*Canis latrans*), whereas Reed and Merenlender (2008) documented (in the same study area as Reilly et al.) densities of these two species more than five times lower in protected areas that permitted recreation versus those that did not. Dertien et al. (2018) identify differences in the following aspects of the two studies: field study methods, statistical analyses,



**Figure 2.** A conceptual model of ecological effects of outdoor recreation (Credit: Monz et al. 2010).

and research design – namely, types of study sites selected, treatment of data sources as replicates or independent of one another, and duration of data collection (one versus three years). These differences may have contributed to the greater variability observed in Reilly et al.'s (2017) study compared to Reed and Merenlender (2008).

Strong variability in other factors that are well known to influence mammalian distributions (e.g., habitat type, human development, or seasonal effects) make it difficult to conclude whether the potential effects of recreation on the target species were truly absent or simply undetected (Dertien et al. 2018). In addition, studies that use abundance, relative abundance, or species richness generally observe stronger effects of recreation than do studies such as Reilly et al.'s (2017) that use occupancy as a response variable (or occupancy interpreted as habitat use; Reed et al. 2019).

Reilly et al. (2017) acknowledge that: species vary widely in their responses to human activities; recreation-related effects on mammalian species that are rare or declining may be greater than on those that are more common or widely distributed; and birds, reptiles, amphibians, and small mammals may respond differently than the large and medium-sized mammals they studied. Finally, in contrasting their results with those of George and Crooks (2006), Reilly et al. do not acknowledge Gill et al.'s (2001) assertion that proximity to other suitable habitat influences how wildlife will respond to human disturbance; George and Crooks (2006) not only acknowledge but give credence to Gill et al.'s work.

## Population-level effects

The foregoing discussion reveals many complexities of recreation ecology and provides a sense of why the population-level effects of human disturbance to wildlife are still poorly known (Burger 2012; Hennings 2017). Parameters used to measure population-level effects include population size, density, age structure, fecundity (birth rates), mortality (death rates), and sex ratio (Tarsi and Tuff 2012). Comprehensive assessments of the nonlethal effects on wildlife at the population level are rarely undertaken due to several constraints, including that robust assessment of these effects is challenging (Pirota et al. 2018). Nonetheless, from a strictly conservation standpoint, human disturbance to wildlife is important only if

**Table 1.** Variables that influence the outcome of studies designed to assess the ecological effects of recreational activities. Each variable is mentioned in one or more of the cited articles (Taylor and Knight 2003; Beale and Monaghan 2004; Markovchick-Nicholls et al. 2007; Davis et al. 2010; Monz et al. 2010; Pickering 2010a; Quinn and Chernoff 2010; Burger 2012; D'Acunto 2018).

a. regional geophysical traits	u. predictability of recreational activity
b. size(s) of protected area(s) where research occurs	v. degree of target animals' habituation to tested activities
c. type(s) of vegetation present	w. duration of target animals' exposure
d. area and density of vegetative cover	x. whether the target animals have the ability to retreat
e. surrounding environment, including vegetation between the recreational activity and the target species	y. type(s) of recreation
f. edaphic conditions (e.g., soil type, level of compaction, moisture, composition)	z. duration of recreational activity
g. weather (temperature, precipitation, wind, shade, sun etc.)	aa. # of humans present (e.g., individuals or groups)
h. timing (day / night / season)	bb. # of human disturbances per day
i. time of day x location	cc. whether recreational activity is on or off an official trail
j. design of trails (e.g., steepness of trails)	dd. recreationists' positions
k. placement of trails (orientation to terrain - on flat, along a slope, across a slope)	ee. angle / trajectory of recreationists' approach to wildlife
l. direction of trails (ascending or descending)	ff. speed and style (e.g., 'aggressive') of recreationists' approach
m. spatial relationship between trails and target animals	gg. distance of recreational travel
n. trail density	hh. whether the recreationists apply best practices
o. wildlife present, target and non-target	ii. recreationists' behavior (e.g., talking or silent, continuous movement or stopping)
p. total # of target wildlife individuals	jj. encounter distance
q. spatial distribution of target wildlife	kk. perpendicular distance
r. age classes and genders of target wildlife present (adult males/females, subadults, young of year)	ll. encounter x perpendicular
s. reproductive status of target wildlife	mm. researcher bias
t. fitness of target wildlife	nn. study methodology (e.g., is recreationists' approach to wildlife direct or tangential, on or off trail; includes statistical analyses)

it affects survival or fecundity such that a population declines (Gill et al. 2001). Assessing and managing the nonlethal effects on wildlife populations has long been a goal of ecologists, land managers, and decision makers (Pirootta et al. 2018). The management of human activities that cause nonlethal effects on wildlife presents a fundamental ecological problem: how to understand the population-level consequences of changes in the behavior or physiology of individual animals that are caused by external stressors (Pirootta et al. 2018). Given the expansion of recreational activities that can disturb wildlife, quantitatively linking the effects of this disturbance to population dynamics is a major objective for modern conservation (Pirootta et al. 2018).

While behavioral responses, which are studied far more often than other types of responses (e.g., physiological; Larson et al. 2016), have the potential to affect survival or reproductive success, the actual fitness<sup>13</sup> costs of behavioral responses need to be quantified before the responses can be used as reliable estimates of population-level perturbations (Gill et al. 2001).

In most situations when statistical models are used to estimate or forecast the population-level effects of disturbance, selection of a model structure is likely to be driven by data availability (Pirootta et al. 2018). Collecting recreation data in conjunction with ongoing animal population monitoring efforts would be a valuable way to improve the understanding of the effects of human disturbance on demographic trends; and, studies that combine behavioral responses with physiological or demographic metrics would help calibrate the relationships between behavioral responses and population-level effects (Reed et al. 2019). Whichever models are used, uncertainty in the estimated population consequence can be reported as a distribution of potential outcomes, allowing the application of the precautionary principle if the results are used to make management decisions (Pirootta et al. 2018).<sup>14</sup> Application of the precautionary principle is warranted given that any simulation model simplifies reality (D'Acunto et al. 2018).

The dearth of conclusive evidence of recreation-related population-level effects in the literature does not mean that such effects are rare; logic dictates that, if the negative consequences of some observed behaviors or physiological changes in wildlife persist, negative population-level effects will eventually follow. For example, negative population-level effects on desert bighorn sheep (*Ovis canadensis nelsoni*) from recreational disturbance have been documented and are implicated in the bighorn sheep abandonment of habitat (and extirpation of the population) in the Pusch Ridge Wilderness in Arizona, USA (Longshore et al. 2013). And, recreation is one reason cited for the population of bighorn sheep in the Peninsular Ranges of California being listed in 1998 as endangered under the Federal Endangered Species Act (USFWS 2000).

The effects of hikers on elk (*Cervus elaphus*) provide another example of recreation-related population-level effects. Based on a two-year study of the response of female elk to the presence of back-country hikers during the calving season, Shively et al. (2005) recommended that some recreational closures be continued because, despite the evidence that elk reproduction can rebound from depressed levels when hikers are removed or reduced in

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<sup>13</sup> Fitness refers to reproductive success and reflects how well an organism is adapted to its environment (Hennings 2017).

<sup>14</sup> The central tenet of the precautionary principle is that precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. Generally, the four central components of the principle are: taking preventive action in the face of uncertainty; shifting the burden of proof to the proponents of an activity; exploring a wide range of alternatives to possibly harmful actions; and increasing public participation in decision making (Kriebel et al. 2001).

number, they could not determine if there is a threshold level of reproductive depression from which elk cannot recover. In fact, a 2019 article in *The Guardian* reported that the number of elk in the same herd Shively et al. (2005) studied had dropped precipitously since the early 2010s with the steady increase in recreation; what was once a herd of 1,000 head of elk, had dropped to 53 at last count in February of 2019 (Peterson 2019). The article explains that, for Bill Alldredge, one of the authors of the study, there is no other explanation than the increased levels of trail users in the area that supports this elk herd (Peterson 2019).

In a study to assess the effects of recreational activities on Iberian frogs (*Rana iberica*), an endemic species in decline and listed as vulnerable in the Spanish Red Data Book, Rodríguez-Prieto and Fernández-Juricic (2005) concluded that (1) the decrease in Iberian frog abundance with the proximity to recreational areas suggests that direct human disturbance affects this species at the population level, and (2) overall, the results suggest that direct human disturbance needs to be considered as a potential factor affecting amphibian populations with low tolerance for disturbance.

From the peer-reviewed recreation ecology literature, Steven et al. (2011) compiled 69 journal articles that describe the results of original research examining the effects of non-motorized nature-based recreation on birds. Among the articles were 33 that examined population-level avian responses (i.e., reproductive success including number of nests, number eggs laid, and number of chicks that hatched or fledged). Negative effects were reported in 85% of these 33 articles.

Patten et al.'s (2017) 10-year study of mammalian populations across the County of Orange Central and Coastal NCCP/HCP protected areas coincided with a marked increase of human activity and provides insight to potential population-level effects. Though the authors did not discern a decline in the populations studied, they did discern temporal and spatial shifts by wildlife due to human presence, and they suggested that the associated losses in prey populations are unsustainable in light of additional stressors these populations face, which range from continued loss of habitat to human disturbance in the protected areas. Furthermore, given the avoidance behavior and temporal shifts of the various mammalian species, any further increase in human disturbance may yet drive mammalian populations downward (Patten et al. 2017).

With regard to population-level effects of anthropogenic fragmentation, evolutionary adaptation to such fragmentation has received some attention. Even when adaptation to fragmentation occurs, it may not be enough to fully compensate for the environmental effects from fragmentation, and in some cases may even exacerbate them (Cheptou et al. 2017).

### **Distinguishing facets of mountain biking**

Together with the extent of the above-discussed creation and use of unauthorized trails and TTFs by mountain bikers, the mass-marketing of the sport, and the very large numbers of mountain bikers (Burgin and Hardiman 2012), at least four facets of mountain biking distinguish it from other recreational activities such that it may be of potentially greater concern with respect to its effects on wildlife than yet accounted for in the literature. These facets are distance traveled, speed of travel, biking in the dark, and political lobbying and advocacy.

*Distance traveled.*—Bikers traveling faster obviously travel farther than hikers per unit time and could therefore disturb more wildlife than hikers per unit time (Taylor and Knight 2003; Burgin and Hardiman 2012); the same applies to bikers and equestrians when bikers travel faster than equestrians. Larson et al. (2016) reasoned that, since motorized activities

often cover larger spatial extents than non-motorized activities, it is possible that the effects of motorized activities have been underestimated. The same logic applies to the distances traveled by bikers and hikers. For valid comparisons among recreation-related ecological effects, the comparisons must account for distances traveled and the associated levels of disturbance to wildlife along the entire route traveled.

*Speed of travel.*—While recreation-related effects on wildlife are generally assumed to be indirect (Dertien et al. 2018), the speed at which mountain bikers travel, combined with their relatively quiet mode of travel, can result in direct disturbance to wildlife. A relatively fast moving, quiet mountain bike may approach an animal undetected until well within the animal's normal flight response zone. The result may be a severe startle response by the animal with significant consequences to the animal and/or the mountain biker (Quinn and Chernoff 2010). The sudden encounter is the most common situation associated with grizzly bear (*Ursus arctos horribillis*) inflicted injury (Quinn and Chernoff 2010). Biking-caused wildlife fatalities likely resulting because of bikers' speed occur with amphibians and reptiles that may be attracted to trails for thermoregulation and are thus exposed to collision with bikes' wheels (Burgin and Hardiman 2012); photo-documentation provides evidence of three such fatalities in CDFW's Del Mar Mesa Ecological Reserve in San Diego where a San Diego horned lizard (*Phrynosoma coronatum blainvillii*, a species of concern under CDFW and the U.S. Fish and Wildlife Service), three western toads (*Anaxyrus boreas*), and two Baja California treefrogs (*Pseudacris hypochondriaca*) were killed by mountain bikes (J. Price, CDFW, personal communication, 2019). The treefrogs appear to have been mating when run over—the photo documentation shows eggs spilling out of the female. Biking is prohibited in this ecological reserve, and two of the run-overs occurred on unauthorized trails (J. Price, CDFW, personal communication, 2019).

Though there are methods (e.g., bells attached to bikes) for mountain bikers to give warning of their approach to other trail users, and these can be effective for this purpose, these methods themselves can introduce additional disturbance to wildlife. And, such warning sounds are ineffective for wildlife whose hearing range does not detect them or who do not hear them soon enough to avoid a collision. Moreover, when recreationists are visible on approach to wildlife, the more threatening (e.g., faster, more direct) the recreationists appear to wildlife (as potential predators), the greater the flight initiation distance from the recreationists (Stankowich 2008). Fleeing from a perceived predator represents potentially needless expenditure of valuable energy.

*Biking in the dark.*—Mountain biking in the dark (i.e., night riding), which is on the rise in protected areas, can disrupt the natural balance between diurnal and nocturnal wildlife. Consequently, night riding poses a dual threat to wildlife that exhibit diel shifts toward night: night riding can compound the pressure such wildlife experience from daytime recreational activities by increasing encounters with competitors and even further reducing the time available for foraging and breeding (Reilly et al. 2017). Night riding can also startle naturally nocturnal wildlife and wildlife that has become increasingly nocturnal to avoid daytime recreationists and other anthropogenic disturbances. Generally, temporal shifts by wildlife involve disruptions to both the shifting wildlife and to the wildlife naturally active during the time frame the shifting wildlife move into. In this way, such shifts set both groups of wildlife up for conflict and competition, disrupt predator/prey relationships, reduce feeding/hunting time and success, and disrupt breeding and other activities (Gaynor 2018). Temporal shifts can also result in spatial shifts and thus potentially cause further ecological

disruptions. Thus, temporal shifts are disruptive not only to individuals, but also to communities, and ultimately, populations (Gaynor 2018).

*Political lobbying and advocacy.*—In part due to the markedly different motivation driving mountain bikers compared to other recreationists in protected areas, especially in the more extreme forms of mountain biking (Burgin and Hardiman 2012), the mountain biking community has come to wield significant lobbying and advocacy pressure throughout the United States. Networking among members of the mountain biking community has resulted in changes in land managers' decisions (Bergin and Hardiman 2012). In California, a newly formed mountain biking nonprofit aims to gain a voice at the capital with lawmakers to put trail access and trail development front and center (Formosa 2019). And, the community has much experience in planning trail networks, experience that is necessary to negotiate areas appropriate for mountain biking. In San Diego County, the local mountain biking coalition and the United States Forest Service (USFS) work in partnership to build trail networks on national forest lands; because the USFS does not have a budget for recreation, the only way trails will be built on national forest lands within the County is if the coalition pays the USFS for the agency's staff time, studies and environmental review, and project-processing needed to approve the trail networks (SDMBA 2017). While the USFS-biking coalition partnership may be similar to the accepted practice of an applicant (e.g., utility) paying a lead/permitting agency to dedicate personnel to the applicant's project(s) or a certain body of work, conflicts of interest are usually inherent in such collaborations. In addition, much of the USFS-biking coalition partnership's planning process occurs outside of public view, prior to the public knowing anything about it. It is notable that, while not all USFS lands are considered protected areas in the meaning of this paper, the wilderness areas the USFS manages are.<sup>15</sup>

## Recommendations and conclusions

Conservation of habitats is critical to the perpetuation of viable populations of sensitive species. California is home to several types of protected areas whose primary or sole purpose is conservation of sensitive species. After conserving these protected areas, the next crucial step in biological conservation is managing how, where, and when humans use the land. However, there is rarely adequate management to control the allowed types and levels of recreation such that they are compatible with conservation, much less prevent the illegal recreation. The following discussion provides recommendations related to the major issues of recreation ecology addressed above. The implementation of most of these recommendations is considered management as the term is used in this paper (footnote #4), and land managers are familiar with most, if not all, of them. Still, it is hoped that the recommendations provide some new insights and even useful guidance for practical application in the management of dual-role protected areas, the wildlife they support, and the recreationists they serve. For simplicity, clarity, and brevity, several of the recommendations are in imperative sentences. For some of the aspects about recreation ecology discussed

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15 The USFS manages approximately 33% of the acreage within the National Wilderness Preservation System (<https://wilderness.net/learn-about-wilderness/agencies.php>) and describes wilderness areas as places where nature "still calls the shots... They are final holdout refuges for a long list of rare, threatened, and endangered species, forced to the edges by modern development... They are places where law mandates above all else that *wilderness* be retained for our current generation, and those who will follow" (<https://www.fs.usda.gov/managing-land/wilderness>).

above, there are no discrete recommendations.

*Continual management is imperative.*—Continual management (footnote #4) of recreation is imperative for dual-role protected areas to meet their conservation objectives. The chronic insufficiency of management resources for protected areas is of obvious concern. It is urgent that action be taken to address the chronically underfunded management of protected areas by securing perpetual fiscal support that is sufficient for the management needs in perpetuity; the perpetual fiscal support to be secured includes all costs for personnel and all program costs. The level of management must be commensurate with expanding levels of authorized and unauthorized non-consumptive recreation. Given the upward trajectory of recreational activities in protected areas, garnering broad support for securing the perpetual fiscal support requires a societal course change to a collective perspective of respecting and tending to other species in need of protection. Management that is effective for the biological resources would also improve the often cited economic, educational, and health benefits of protected areas.

*Prevent further use and proliferation of unauthorized trails.*—Prevent the creation and use of unauthorized trails in the first place. This approach would be far preferable to having to contend with the damage to the ecological resources and cultural ecosystem services (discussed below) from the creation and use of unauthorized trails in protected areas. Here, prevention requires continual management. Consider the lessons learned from the work Greer et al. (2017) describe, as summarized above. Where feasible, gain the trail user community's support for and involvement in proactive efforts to prevent vandalism.

*Restore habitat to reverse internal fragmentation.*—It is reasonable to assume that the disturbance to wildlife from internal fragmentation associated with authorized trails and from legal recreation on them, occurs at least as much from fragmentation associated with unauthorized trails and recreation on them. The internal trail-related fragmentation and expansion of the effect zone most negatively affects those species for which the fitness costs of disturbance are high but have little or no excess habitat to move to; these species are thus constrained to stay in disturbed areas and to suffer the costs in terms of reduced survival or reproductive success (Gill 2001). For these species, restoring the habitat lost to inappropriate trails (i.e., unauthorized trails, unnecessarily redundant designated trails, and trails to be decommissioned) is critical from the standpoint of the negative recreation-related population-level effects. Using restoration to minimize the effects of recreation within fragmented protected areas in urban areas might enable the fragments to better support the focal species (Reed et al. 2019).

Therefore, though the effects on wildlife from unauthorized trails and recreation, per se, have received comparatively little formal study, the precautionary principle (Kriebel et al. 2001; footnote #14) dictates that there seems no need for further study to justify prioritizing restoration of habitat lost to inappropriate trails. So, for levels of habitat loss and the associated internal fragmentation that meet some yet-to-be-established criteria, the restoration should occur. If there is competition for resources (budget/funding, personnel) between (1) research on recreation-related disturbance to wildlife and (2) restoration of habitat lost to inappropriate trails to stop the disturbance, the latter should take priority to reverse internal fragmentation.

To assess the effects of the restoration on the wildlife communities within the protected area, conduct biological surveys within a year prior to the restoration and three to five years after the completion of the groundwork and planting. For this assessment, valid pre-disturbance wildlife survey data collected prior to the loss of habitat within the footprint



of the trails that will be restored and associated effect zone will help. But if there are no pre-disturbance data for the protected area or a nearby undisturbed control area, care must be taken in the interpretation of the results of the survey conducted a year prior to the restoration (i.e., the first survey). This is because the results of the first survey will likely represent wildlife communities altered from the pre-disturbed condition (Hennings 2017). It may be that the level of fragmentation, recreation, and many other factors, have caused conditions in which there are no or very few individuals of the focal species (Hennings 2017). These are reasons to be conservative in estimating the recreation-related effects on wildlife in disturbed protected areas without pre-disturbance data; if wildlife have already vacated the disturbed site before the first survey is done, the results will underestimate disturbance effects on wildlife (Hennings 2017). Here, the purpose of the survey data is to aid in determining how the restoration affects the occurrence and/or density of species (depending on the survey methodology), all other factors being equal. The assessment must account for whether the restoration involves the cessation of recreational activities on and/or in the vicinity of the trails to be restored, especially if no other recreational activities begin elsewhere within the species' effect zone throughout the restoration period. If there is funding available and a desire to monitor human activity and wildlife within the restoration areas, deploy camera traps within the areas; camera traps are the most cost-effective method currently available to monitor wildlife activity (Burger 2012).

Minimally, include the following tasks in the restoration: track the actual and in-kind costs (personnel, capital costs, volunteer hours, etc.) for the entire process; map the inappropriate trails and constructed trail features (some use of aerial imagery may work, but on-the-ground mapping validation is essential; Dertien et. al. 2018); prioritize the order of their restoration; determine the best approach for restoring each trail (e.g., passive, active, or a combination); do the restoration itself;<sup>16</sup> and, monitor for several years. Finally, publicize the costs of the restoration to inform the public (F. Landis, California Native Plant Society, personal communication, 2017); for this, compare the costs of the restoration with the costs of the management (footnote #4) that would have been necessary to prevent the damage requiring the restoration. Reasons for documenting the costs include being able to provide to local and state elected officials comparisons of the costs of reactive and proactive approaches to management, and to inform the public about the costs of repairing ecological vandalism.

If possible and logistically advantageous, it would be prudent and economically beneficial to collaborate with recreationists to volunteer with the restoration. For example, this would be an opportunity to mobilize well-organized volunteer contingents of the mountain biking community that are dedicated to building trails. In fact, in some areas, the mountain biking community provides well-organized volunteer assistance in the designing, building, and/or maintenance of officially designated trails in and outside of protected areas. Such volunteer dedication to the restoration of unauthorized trails is sorely needed.

In addition to the biological benefits, another motivation for this habitat restoration in protected areas is its potential to improve the human experience in protected areas open to public access. California's State Wildlife Action Plan (CDFW 2015) and much of the literature about recreation-related ecological effects point to the economic, educational, and recreational/health benefits (i.e., cultural ecosystem services) of protected areas and the species they support. Regarding the human health benefits, the visible recreation-related

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<sup>16</sup> Here, restoration encompasses decompacting the soil, building back and stabilizing the damaged or destroyed terrain and soil, and restoring the affected native plant communities.

damage to the terrain requires consideration beyond its ecological effects—it also affects the level of benefit people enjoy while being in nature, as illustrated by a study examining the relationship between recreational impacts in protected areas and human mental/emotional states (Taff et al. 2019). The study's results demonstrate that, as visible recreation-related ecological impacts increased, sense of wellbeing and mental state decreased, especially in response to settings with unauthorized trails. Collectively, the results show that managing tourism in protected areas in a manner that reduces such impacts is essential to optimizing beneficial cultural ecosystem services related to human health and wellbeing (Taff et al. 2019). Also diminishing the human experience is the risk of injury when using unauthorized trails and TTFs (Davies and Newsome 2009), a risk that restoration would remove. The benefits of the cultural ecosystem services from habitat restoration may increase the potential to obtain funding for such restoration.

*Use science-based disturbance thresholds and the precautionary approach.*—Establish and use science-based disturbance thresholds to guide management, recognizing and accounting for the notion that the imprecision of thresholds applies to all species, even those for which quantitative thresholds for known sources of disturbances under specific conditions have been identified; thresholds may not adequately protect the target focal species under all conditions in which they occur. The determination of disturbance thresholds must consider the influence of trail-related expansion of effect zones, especially with respect to reductions in the proportions of protected areas that are suitable for wildlife.

To compensate for the imprecision of thresholds when using them to guide management, (1) apply a precautionary approach that adopts maximum values of quantitative disturbance thresholds observed for the taxa of concern, while excluding the extreme values of the thresholds (Dertien et al.'s 2018),<sup>17</sup> (2) take into account that the default position should be a precautionary approach that assumes a priori that the functional value of species' abundance is high (Baker et al. 2018), (3) employ continual proactive and adaptive management to protect wildlife from recreational disturbance,<sup>18</sup> and (4) restrict access if the management fails. The need for the precautionary approach stems from the gaps in knowledge about quantitative disturbance thresholds of recreation.

*In trail and trail network planning, use the best available science.*—When planning new or modifying existing trails and trail networks in protected areas, the best available science ought to guide policy and decision-making about the siting, design, and alignment of the trails, and about the types, levels, and timing of recreation under consideration. To protect the sensitive species, the policy and decision-making should factor in the capacity to manage the existing and planned trails and recreation in perpetuity. No matter how high the pressure from recreationists for more recreational trails and opportunities, it must be recognized that the majority of recreation-related effects on wildlife are negative. The implications of this necessitate thorough consideration as to whether recreational accommodations that are being considered (in conjunction with all other anthropogenic effects) are compatible with

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<sup>17</sup> The precautionary approach and the precautionary principle (footnote #14) have subtle differences between them, but consideration of the differences is beyond the scope of this paper.

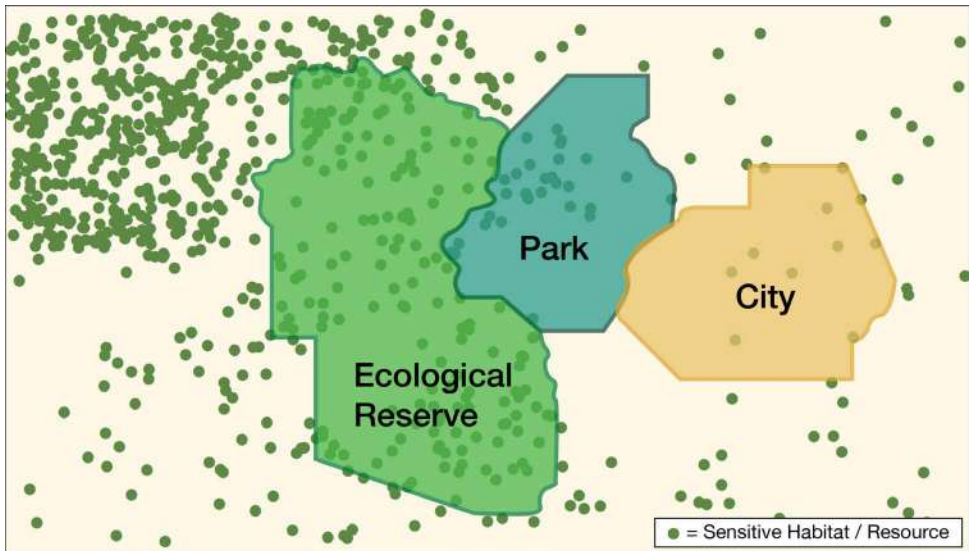
<sup>18</sup> Based on section 13.5 of the California Fish and Game Code (FGC) and the Natural Community Conservation Planning Act (i.e., section 2805 of the FGC), adaptive management generally means (1) improving management of biological resources over time by using new information gathered through monitoring, evaluation, and other credible sources as they become available, and (2) adjusting management strategies and practices accordingly to assist in meeting conservation and management goals (e.g., conservation of covered or focal species). Under adaptive management, program actions are viewed as tools for learning and to inform future actions. Adaptive management is a cornerstone of large-scale multiple species conservation (CDFW 2014).

the protected areas' conservation objectives. The planning should incorporate protective disturbance thresholds, allowing for adaptive modifications as needed. In situations where recreation has been assumed to meet the conditions of compatibility (e.g., as negotiated in NCCPs/HCPs), great care is needed to ensure the veracity of this assumption. The outcome of the planning process should be ecologically soundly designed, sited, and aligned trails and trail networks, with science-based restrictions on types, levels, and timing of recreation. In conjunction with new trail/trail network construction, restore the habitat lost to inappropriate trails within the area of the construction.

*For future protected areas, plan separate recreational areas.*—Planning for future protected areas and associated trail networks and recreational areas holds the greatest potential for successful collaboration among landowners, agencies, recreationists, and other stakeholders that allows for truly protective conditions for sensitive species with respect to recreation. Perhaps it is not too late for California to redirect the trajectory of the recreational juggernaut toward an inspirational conservation success story, where stakeholders come together in the planning process, and apply the prevailing science regarding recreation-related disturbance to wildlife to ensure the perpetuation of viable populations of wildlife in the very protected areas set aside primarily or solely for that purpose. Representatives of the recreation community should sit at the table when planning future protected areas and associated trail networks and recreational areas (Burgin and Hardiman 2012); if the outcome is acceptable to them, it may prevent or minimize the creation of unauthorized trails. For example, without a strong strategic approach to mountain biking that includes community engagement, the outcome will be further degradation of protected areas and, at the least, loss of individuals of wildlife, if not major threats to wildlife populations; it's likely that there will also be on-going conflict between mountain bikers and other recreationists and residents (Burgin and Hardiman 2013).

The limited availability of resources for management suggests that it may be more effective to allocate recreational uses and conservation targets among different sites, which will require a diverse suite of land conservation strategies (Reed and Merenlender 2008). At least until such time that there is management of recreation in protected areas commensurate with recreational pressure, planning for future protected areas should heed what has been commonly known for at least 60 years: if conservation of land occurs without enforcing quotas on visitors, then separate areas need to be provided to accommodate recreational activities elsewhere so that the protected land will not bear the burden of those activities (Wilson 2019). This sentiment applies far more today, principally to protected areas preserved primarily or solely for the perpetuation of sensitive species. While this approach is infeasible for many established protected areas (most protected areas in urban areas), going forward, this ought to be the paradigm of habitat and species conservation in areas of high recreational pressure.

Figure 3 depicts an idealized vision of conservation planning using this approach. For protected areas established pursuant to NCCPs/HCPs negotiated in urban settings within an already fragmented landscape, there is often limited latitude for separate areas for recreation; furthermore, sensitive species are typically distributed more evenly across the urbanized landscape than depicted in Figure 3. Nevertheless, it represents the fundamental approach of separating conservation areas from recreational areas. Even in constrained areas, if planning for recreational access occurs at the regional level, planners and land managers could ensure that protected area networks include some areas that are closed to recreation, thus



**Figure 3.** Effective planning for protected areas preserved primarily or solely for the perpetuation of viable populations of sensitive species: provide separate areas for conservation (e.g., ecological reserves) and recreational activities (i.e., parks). (Credit: Landscape Conservation Planning Program, CDFW 2020)

balancing the dual land uses of conservation and recreation at the scale of the protected area network instead of each individual protected area (Reed et al. 2019). Formally incorporating wildlife considerations into the trail planning process from the start is essential to reducing recreation-related disturbance to wildlife; if trail planning is well underway by the time wildlife is considered, it may be too late to gather sufficient wildlife information to inform the planning process (Hennings 2017).

A consideration often not made in conservation planning is the need to address the temporal aspect of human-wildlife interactions. For example, similar to seasonal restrictions, diurnal or nocturnal “temporal zoning” may be necessary to restrict certain human activities during times of the day when sensitive species are most active or when the likelihood of negative human-wildlife encounters is greatest (Gaynor 2018; Whittington 2019). The effectiveness of temporal closures likely depends on the amount and quality of habitat, and levels of human use and fragmentation, within the planned protected areas and in the surrounding landscape. Temporal closures may not benefit wildlife with diurnal activity patterns that differ from the timing of the temporal closures; so, full closures may be required to increase wildlife use in many situations (Whittington 2019). For situations when protected areas and recreational areas are separate but share a boundary, temporal zoning would also apply to the effect zone within the recreational area.

*Conclusion.*—The most sensible approach for species conservation may be to concentrate research and protection efforts on species whose populations are declining and for which human disturbance is implicated as a possible cause (Gill et al. 2001). The designation of ecological reserves and the conservation of habitat pursuant to NCCPs/HCPs are examples of processes that embody this approach. But, when recreation in such protected areas is not properly planned and adequately managed, their ecological viability and ability to meet their conservation objectives are jeopardized. Implementation of the recommendations provided

herein is necessary to ensure the focal species thrive.

Ultimately, for wildlife that avoids human activity, it is unlikely that dual-role protected areas are entirely sufficient or justifiable for meeting conservation objectives; limiting or prohibiting recreation in strategic circumstances and locations within protected areas is necessary to achieve conservation objectives (Bötsch et al. 2018; Dertien et al. 2018; Reed et al. 2019). Enforced closures of inappropriate trails in all protected areas and restoration of those trails would substantially decrease the trail-related disturbance to wildlife across the landscape; waiting until after wildlife detections or estimates of habitat use decrease is too late to implement these measures (Dertien et al. 2018). These approaches require perpetual management commensurate with expanding levels of authorized and unauthorized non-consumptive recreation in protected areas. Action is urgently needed to secure perpetual fiscal support for management sufficient to ensure the perpetuation of viable populations of sensitive species in protected areas.

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## INFORMATION FOR AUTHORS

*The California Fish and Wildlife Journal* (CFWJ) is a peer-reviewed, scientific journal focused on the biology, ecology, and conservation of the flora and fauna of California and surrounding areas, and the northeastern Pacific Ocean.

Submissions guidelines (PDF) for the Journal have been updated (July 2019).

*The California Fish and Wildlife Journal* accepts manuscripts in the following categories:

- Original research papers
- Research notes
- Review papers
- Book reviews
- Commentaries and Essays

Manuscripts must be submitted by e-mail following directions provided in the link: <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=171113&inline>. The journal standard for style is consistent with the Council of Science Editors (CSE) Style Manual. Instructions in the CFWJ guidelines supersede the CSE Style Manual where differences exist between formats. Please follow these formatting guidelines carefully. Manuscripts that do not conform to the guidelines will be returned for revision.

Authors of manuscripts that are accepted for publication will be invoiced for charges at the rate of \$50 per printed page shortly after page proofs are distributed.\* Authors should state acceptance of printing charges in their cover letters. The corresponding author will receive a PDF file of the publication without additional fees and may distribute copies without restriction.

\*Page charges may be waived for authors under in certain instances (e.g., for authors from developing countries or students without funding). If applicable, please request a waiver in your cover letter.

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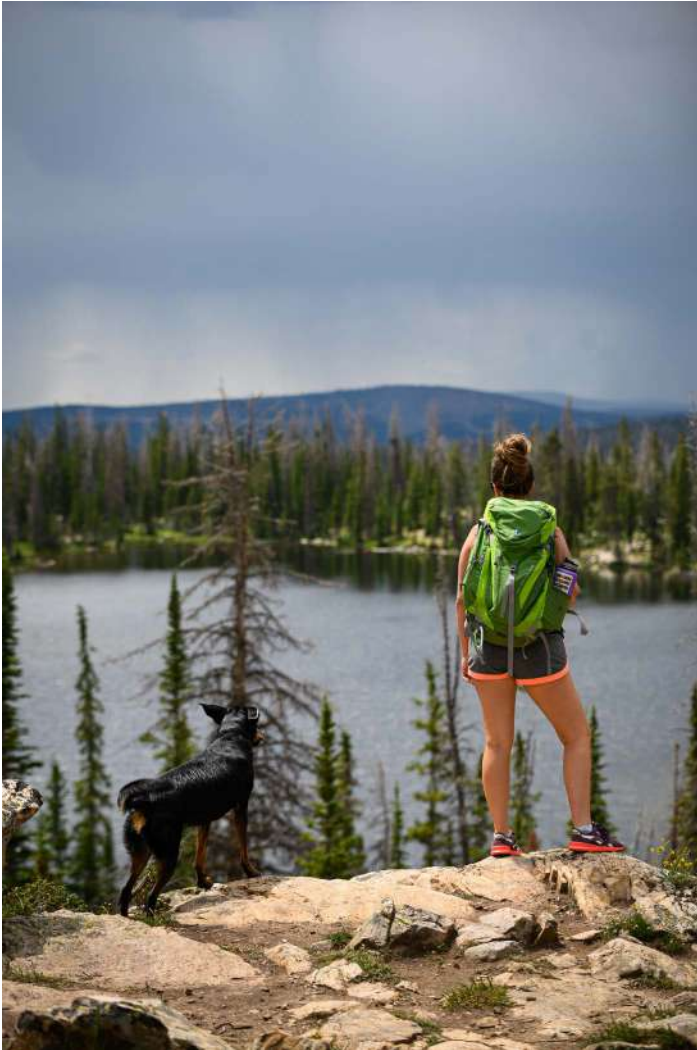


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# EXHIBIT C

Addendum to: Report on adequacy of analyses and likely impacts of management for the “Fish and Wildlife” and “Special Status Species” portions of BLM Draft C-CD RMP/EA

7/24/2020

Jacob F. Pollock PhD, Biological Researcher, Conservation Planner, Monitoring Plan Analyst.

A recent issue of the California Fish and Wildlife Journal (Recreation Special Issue 2020) contains 8 peer-reviewed research papers that synthesize and summarize current scientific thought about incompatibilities between recreational use (aka, “non-consumptive use”) and protection of wildlife and habitats in natural areas. Several of the articles document the negative effects of recreational use and a couple articles have suggestions for frameworks for balancing the two opposing management goals.

What the articles make clear is that these two management goals, recreational use and wildlife protection, are opposed to each other: more recreational use means less protection for wildlife. Additionally, the articles make it clear that managers must understand these incompatibilities and account for them in their planning and management. Specifically, for the management of Cotoni-Coast Dairies by BLM, given the unambiguous mandate to protect its wildlife and their habitats, managers need to explicitly study, understand and mitigate the effects of recreational use. The articles provide suggestions for how to collaborate with recreationalists and ecologists and how to mitigate the effects of recreation – including the option of excluding recreational use. The BLM should use one or more of these tools to create a collaborative framework among ecologists and recreationalists.

A full EIS should be conducted in order to review these 8 new publications and the references contained within them to adequately protect the wildlife and habitats within the monument if recreational use is to be considered for Cotoni-Coast Dairies. Most of these papers are review papers and thus the references within these papers are also crucial for an understanding of the effects of recreation upon wildlife and their habitats.

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California Fish and Wildlife Journal. Recreation Special Issue.



# EXHIBIT D

**FILED**

JUN 3 2020

MOLLY C. DWYER, CLERK  
U.S. COURT OF APPEALS

**FOR PUBLICATION**

UNITED STATES COURT OF APPEALS

FOR THE NINTH CIRCUIT

NATIONAL FAMILY FARM  
COALITION; CENTER FOR FOOD  
SAFETY; CENTER FOR BIOLOGICAL  
DIVERSITY; PESTICIDE ACTION  
NETWORK NORTH AMERICA,

Petitioners,

v.

U.S. ENVIRONMENTAL PROTECTION  
AGENCY; ANDREW WHEELER, in his  
official capacity as Administrator,

Respondents,

MONSANTO COMPANY,

Respondent-Intervenor.

No. 19-70115

Environmental Protection Agency

**OPINION**

On Petition for Review of an Order of the  
U.S. Environmental Protection Agency

Argued and Submitted April 21, 2020  
San Francisco, California

Before: Michael Daly Hawkins, M. Margaret McKeown, and William A. Fletcher,  
Circuit Judges.

Opinion by Judge W. Fletcher

American farmers have been using dicamba, a chemical herbicide, to combat weeds for more than fifty years. Dicamba is an effective weed killer, but its toxicity is not limited to weeds. It can kill many desirable broadleaf plants, bushes, and trees. It also has a well-known drawback. Dicamba is volatile, moving easily off a field onto which it has been sprayed. It can drift if the wind blows during application; it can drift if applied during temperature inversions; it can drift after application when it volatilizes, or turns to a vapor, during hot weather. As a result of its toxicity and its tendency to drift, dicamba had historically been used to clear fields, either before crops were planted or before newly planted crops emerged from the soil. This changed in 2017.

By the early 2000s, many weeds had developed a resistance to the widely used herbicide glyphosate, the main ingredient in Roundup brand-name products sold by the Monsanto Company (“Monsanto”). In response, Monsanto developed and patented genes that allowed soybean and cotton crops to tolerate dicamba. Concurrently, Monsanto and two other herbicide manufacturers reformulated dicamba herbicides in an attempt to make dicamba less volatile and therefore usable during the growing season. Their efforts culminated in 2016, when, pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (“FIFRA”), 7 U.S.C. §§ 136 *et seq.*, the U.S. Environmental Protection Agency (“EPA”) granted conditional, two-year amended registrations to Monsanto and later the two other

agrochemical companies, approving their reformulated dicamba-based herbicides for over-the-top (“OTT”), or “post-emergent” use on dicamba-tolerant (“DT”) soybeans and cotton ahead of the 2017 growing season. The conditional registrations were to expire in late 2018.<sup>1</sup>

On October 31, 2018, the EPA approved conditional registrations for the three dicamba-based herbicides for an additional two years. The EPA’s decision document announced that the EPA “will be granting requests by Bayer CropScience (formerly Monsanto Company), Corteva (formerly DuPont), and BASF to amend their existing conditional registrations that contain expiration dates of November 9, 2018, and December 20, 2018, respectively.” In the following week, the EPA issued conditional two-year amended registrations to Bayer for its “M1768 Herbicide,” also known as “XtendiMax With VaporGrip Technology” (“XtendiMax”); to Corteva for its “DuPont FeXapan Herbicide” (“FeXapan”); and to BASF for its “Engenia Herbicide” (“Engenia”).

The National Family Farm Coalition, Center for Food Safety, Center for Biological Diversity, and Pesticide Action Network North America (“petitioners”) sought review of the October 31, 2018, decision upon which the registrations were

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<sup>1</sup> For the convenience of the reader, we list here the key abbreviations used in this opinion. “Over-the-top” (dicamba use) is abbreviated “OTT.” “Dicamba-tolerant” (soybean and cotton) is abbreviated “DT.” The Office of Pesticide Programs (housed within the EPA) is abbreviated “OPP.”

based. Petitioners argue that the EPA's decision violates both FIFRA and the Endangered Species Act, 16 U.S.C. § 1536(a)(2).

We hold that the EPA's October 31, 2018, decision, and the conditional new-use registrations of XtendiMax, Engenia, and FeXapan for use on DT soybean and cotton that are premised on that decision, violate FIFRA. As we will explain in more detail below, FIFRA provides two requirements for conditional amendment of an existing registration. The EPA must determine that (i) the applicant has submitted "satisfactory data," and (ii) the amendment will not "significantly increase the risk of any unreasonable adverse effect on the environment." 7 U.S.C. § 136a(c)(7)(B). We need not decide whether substantial evidence supports a finding that the applicants submitted satisfactory data—although, as we discuss below, the data have several flaws—because we hold that the EPA substantially understated risks that it acknowledged and failed entirely to acknowledge other risks.

The EPA substantially understated three risks that it acknowledged. The EPA substantially understated the amount of DT seed acreage that had been planted in 2018, and, correspondingly, the amount of dicamba herbicide that had been sprayed on post-emergent crops. Further, the EPA purported to be agnostic as to whether formal complaints of dicamba damage under-reported or over-reported the actual damage, when record evidence clearly showed that dicamba

damage was substantially under-reported. Finally, the EPA refused to estimate the amount of dicamba damage, characterizing such damage as “potential” and “alleged,” when record evidence showed that dicamba had caused substantial and undisputed damage.

The EPA also entirely failed to acknowledge three other risks. The EPA entirely failed to acknowledge record evidence showing the high likelihood that restrictions on OTT dicamba application imposed by the 2018 label would not be followed. The EPA based its registration decision on the premise that the label’s mitigation measures would limit off-field movement of OTT dicamba. These measures became increasingly restrictive with each iteration of OTT dicamba labels. Record evidence shows that the restrictions on the 2016 and 2017 labels had already been difficult if not impossible to follow for even conscientious users; the restrictions on the 2018 label are even more onerous. Further, the EPA entirely failed to acknowledge the substantial risk that the registrations would have anti-competitive economic effects in the soybean and cotton industries. Finally, the EPA entirely failed to acknowledge the risk that OTT dicamba use would tear the social fabric of farming communities.

We therefore vacate the EPA’s October 31, 2018, registration decision and the three registrations premised on that decision. Because our vacatur is based on

our holding under FIFRA, we do not reach the question whether the registration decision also violates the Endangered Species Act.

## I. Background

### A. Evolution of Glyphosate-Resistant Weeds

Before its purchase by Bayer in 2018, Monsanto had become a household name largely due to its flagship herbicide Roundup. In the 1990s, Monsanto developed a “Roundup Ready” crop system, selling this glyphosate-based herbicide along with seeds genetically modified to tolerate glyphosate. Monsanto’s Roundup Ready system allowed farmers to apply glyphosate over genetically modified crops during the growing season, killing weeds but leaving their crops unharmed. By 2008, 92 percent of soybeans and 68 percent of cotton plantings in the United States came from glyphosate-resistant seeds. Glyphosate was so popular that many farmers sold their weed-tilling equipment and stopped buying other herbicides, instead applying glyphosate on their fields year after year.

After years of heavy glyphosate use by farmers, many weeds developed glyphosate resistance. Such “superweeds” include Palmer amaranth, a large and fast-growing weed that, left unchecked, can take over a field. In search of a new weed-killer, Monsanto and other agrochemical companies turned to dicamba, which had been registered for limited use since 1967. Dicamba works by mimicking auxin, a plant hormone, to cause abnormal and ultimately fatal cell

growth. Dicamba is extremely toxic to broadleaf plants, bushes, and trees. It can damage or kill fruiting vegetables, fruit trees, grapes, beans, peas, potatoes, tobacco, flowers, and ornamental plants. It can also damage or kill many species of large trees, including oaks, elms, and maples. Dicamba damage is easily identified by its signature marker, “leaf cupping.”

Dicamba’s toxic effect is magnified by its tendency, shared with other synthetic auxins, to move off a field where it is sprayed. Dicamba droplets can drift during or shortly after spraying if the wind is blowing too hard or the spraying equipment is moving too fast. Dicamba vapor can drift if dicamba is applied during a temperature inversion—an atmospheric condition in which cool air at the earth’s surface traps warmer air above it, allowing the vapor to remain in a concentrated cloud and move off-field during a light wind. And dicamba vapor can drift if dicamba volatilizes after it has come to rest on plants or the ground. Dicamba can volatilize hours or even days after it has been applied, and it does so more easily and in greater volumes as the temperature rises. During temperature inversions, or after volatilizing on hot days, dicamba can drift long distances, sometimes a mile or more.

Because of its tendency to drift, dicamba had been largely used in late winter or early spring before crops were planted. Post-emergent use of dicamba was



limited to crops that are naturally tolerant of dicamba, such as corn and wheat, and was typically limited to use early in the growing season.

B. Development of Lower-Volatility Dicamba Herbicides and EPA's 2016 Two-Year Conditional Registration Decision

Monsanto and two other agrochemical companies—DuPont and BASF—developed new dicamba products with reduced (though not eliminated) volatility. The companies claimed to the EPA that their new dicamba herbicides had such low volatility that they were unlikely to move in significant amounts off the field to which they were applied and could therefore be used safely during the growing season. In 2010 and 2012, Monsanto submitted applications to the EPA to register two different formulations of dicamba-based herbicide for post-emergent use on genetically modified, dicamba-tolerant (“DT”) soybeans and cotton.

In 2015, the U.S. Department of Agriculture deregulated DT soybean and cotton seeds under authority granted by the Plant Protection Act, 7 U.S.C. §§ 7701 *et seq.* Monsanto, which had developed and patented the dicamba-tolerance seed trait, began to sell these DT seeds ahead of the 2016 growing season, before the companion dicamba herbicides had been approved by the EPA for over-the-top (“OTT”) use. Farmers planted about 1.7 million acres of DT soybeans and close to 50,000 acres of DT cotton in 2016. Record evidence contains reports that some

growers illegally sprayed the old dicamba herbicides during the post-emergent phase of the 2016 growing season.

Under FIFRA, the EPA can conditionally amend the registration of a pesticide (including an herbicide) to permit an additional use only if it finds that the new use will not significantly increase the risk of any unreasonable adverse effect on humans or the environment, taking into account the pesticide's economic, social, and environmental costs and benefits. *See* 7 U.S.C. § 136a(c)(7)(B) (allowing the EPA to conditionally amend the registration of a pesticide to allow for a new use); § 136(bb) (defining “unreasonable adverse effects on the environment” to include “any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide”).

Beginning in the fall of 2016, the EPA announced that it would grant two-year conditional registrations for three lower-volatility, OTT dicamba herbicides—Monsanto's XtendiMax; DuPont's FeXapan; and BASF's Engenia. In support of its decision, the EPA identified two “important” benefits from OTT application of dicamba on DT soybeans and cotton. First, dicamba “provides an effective tool to treat especially noxious weeds . . . including glyphosate-resistant biotypes that threaten soybean and cotton production today.” Second, “effective treatment of glyphosate-resistant weeds can help control the spread of resistance.”

The EPA stated that the lower-volatility dicamba formulations, if used in compliance with restrictions on an approved label, posed little or no risk of adverse effects on the environment and therefore imposed minimal costs. In its registration decision, the EPA wrote that the label restrictions “are known to profoundly impact any drift potential from pesticide application.” “In aggregate, these formulations and labeling requirements are expected to eliminate any offsite exposures and effectively prevent risk potential to people and non-target species.” The EPA concluded, “After weighing all the risks of concern against the benefits of the new uses, the EPA finds that when the mitigation measures for these uses are applied, the benefits of the use of the pesticide outweigh[] any remaining minimal risks, if they exist at all.”

The conditional registrations allowed OTT dicamba use in thirty-four states.<sup>2</sup> The conditional registrations for XtendiMax and FeXapan were set to expire on November 9, 2018; the conditional registration for Engenia was set to expire on December 20, 2018. The EPA wrote that the conditional registrations would

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<sup>2</sup> The states are Alabama, Arizona, Arkansas, Colorado, Delaware, Florida, Georgia, Illinois, Iowa, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia, and Wisconsin.

automatically expire unless the agency determined that off-site incidents of dicamba damage were not occurring at “unacceptable frequencies or levels.”

The EPA’s 2016 registration decision required a detailed label restricting the manner in which the dicamba-based herbicides could be used. The most important restrictions were: (1) application was prohibited during wind speeds above fifteen miles per hour; (2) application was prohibited during temperature inversions; (3) application was prohibited if rain was expected in the next twenty-four hours; (4) application was prohibited when spraying equipment was traveling at a ground speed above fifteen miles per hour; (5) a buffer of at least 110 feet between the last treated crop row and the nearest downwind edge of the field was required; and (6) a maximum sprayer boom height of twenty-four inches above the weeds or crop canopy was required.

#### C. Experience During the 2017 Growing Season, and Label Amendment for the 2018 Growing Season

XtendiMax, Engenia, and FeXapan were on the market in time for the 2017 growing season. Many farmers adopted the new crop system, planting seeds with Monsanto’s dicamba-tolerance trait on 27 million acres and using dicamba herbicides on the post-emergent crops. From 2012 to 2016, before use of OTT dicamba was allowed on DT soybeans and cotton, an average of 231,000 pounds acid equivalent of dicamba had been applied each year to cotton, while an average

of 537,000 pounds of dicamba had been applied to soybeans. In 2017, almost 8 million pounds of dicamba were applied to post-emergent soybeans, and almost 2 million pounds were applied to post-emergent cotton.

In its 2016 registration decision, the EPA had written that the label restrictions were “expected to eliminate *any* offsite exposures” to dicamba. (Emphasis added.) But as the 2017 growing season progressed, complaints of dicamba-caused damage to commercial crops and other plants soared. By the end of the season, according to a report by Professor Kevin Bradley of the University of Missouri, 2,708 formal complaints of dicamba-caused damage were being investigated by state departments of agriculture. Bradley reported that university weed scientists estimated that approximately 3.6 million acres of soybeans in twenty-four states, or about 4 percent of all U.S. soybean acreage, were damaged by off-field movement of dicamba.

Reuben Baris, Acting Chief of the herbicide branch of the EPA’s Office of Pesticide Programs, told state regulatory officials at a meeting in Washington, D.C., in the fall of 2017 that the agency was “very concerned with what has occurred” with the OTT use of dicamba. During a presentation in September 2018, Baris confirmed that “[m]ore than 3.6 million acres” of soybeans had been damaged by dicamba during the 2017 season. Baris noted, further, that the reported damage was likely an underestimate of the actual damage because, in his

words, “[n]ot all reports of crop damage were reported to State Departments of Agriculture.” Speaking on the topic of dicamba at an annual meeting of the Pesticide Stewardship Alliance in February 2018, Rick Keigwin, the Director of the EPA’s Office of Pesticide Programs, remarked, “I don’t say this in jest, but 2018 cannot look like 2017.”

Monsanto proposed changes to the XtendiMax label for the 2018 growing season to address what the EPA characterized as a “high number of crop damage incidents.” The EPA also consulted state agencies and the U.S. Department of Agriculture on the changes, but it did not undertake a formal registration amendment process before approving additional label restrictions for the OTT dicamba products for the 2018 season. The most important additional restrictions were: (1) application was prohibited if the wind speed during application was less than three miles per hour or more than ten miles per hour (rather than more than fifteen miles per hour); (2) application was permitted only between sunrise and sunset (rather than at any time other than during a temperature inversion); (3) the herbicides had to be labeled as “restricted use pesticides,” which could be applied only by certified applicators or people working under their direct supervision; and (4) applicators had to receive dicamba-specific training.

In a letter to Monsanto adopting the changes, the EPA wrote, “The amendment approved through this letter includes additional restrictions further

minimizing off-field movement of the active ingredient dicamba and do not affect the conclusions in the supporting assessment of risk. EPA accordingly continues to rely on all the assessments that supported the new uses, and therefore does not require . . . [any] new risk assessment.” In other words, the EPA continued to rely on its risk assessment from a year earlier, when it had concluded that the 2016 labeling requirements “are expected to eliminate any offsite exposures and effectively prevent risk potential to people and non-target species.”

#### D. Experience During the 2018 Growing Season

In 2018, more than 103 million acres of soybeans and cotton were planted in the United States. Of that total, 56 million acres were planted with seeds with Monsanto’s dicamba-tolerance trait, up from 27 million acres the year before. Bradley reported that by July 15, 2018, university weed scientists estimated that in eighteen states there were about 1.1 million acres of soybeans with dicamba damage. The other sixteen states where OTT dicamba was approved were not included in the report. By the same date the previous year, Bradley reported, university weed scientists had estimated 2.5 million acres of damaged soybeans. It is unclear how many states were included in the July 2017 estimate.

The 2018 growing season was again marked by many complaints of off-site dicamba damage. In the country’s major soybean-producing states, the sharp increase in 2017 of complaints to state agriculture departments about dicamba

damage to crops was followed by only a slight decrease in complaints in 2018. In 2017 and 2018, Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota planted the most acres of soybeans. *See Quick Stats*, NAT'L AGRIC. STATISTICS SERV., <https://quickstats.nass.usda.gov/results/96B2EF56-2AC3-329E-803E-6D6D3CC5444C>. In those states in 2017, there were 1,287 complaints to state departments of agriculture of dicamba damage; in 2018, there were 1,064 complaints. In total, according to the Association of American Pesticide Control Officials, approximately 1,400 complaints of crop damage resulting from OTT dicamba herbicides were reported to state regulatory authorities in 2018.

There were substantial differences from state to state in reported dicamba damage in 2018. Some states imposed restrictions for the 2018 growing season over and above the label requirements imposed by the EPA and experienced substantial decreases in the number of dicamba complaints. For example, in 2018 Minnesota imposed two additional restrictions on OTT application of dicamba herbicides: (1) after June 20, OTT application of dicamba was forbidden; and (2) before June 20, OTT application of dicamba was forbidden on days when field temperatures exceeded 85 degrees. In 2017, there were 250 complaints of dicamba-related crop damage in Minnesota; in 2018, there were 29. Similarly, in 2018 Arkansas prohibited OTT applications of dicamba between April 16 and



October 31, effectively banning its use during the growing season. In 2017, there were 986 complaints of dicamba-related crop damage in Arkansas; in 2018, there were 200. By contrast, in 2018 Illinois imposed no additional requirements beyond those on the EPA label. In 2017, there were 245 complaints of dicamba-related crop damage in Illinois; in 2018, the number of complaints *increased* to 330.

#### E. 2018 Registration Decision

With the 2016 conditional registrations due to expire in late 2018, Bayer (Monsanto's new owner), Corteva, and BASF sought amendments that would extend the registrations for another two years. On October 31, 2018, the EPA announced it would "be granting requests by Bayer CropScience (formerly Monsanto Company), Corteva (formerly DuPont), and BASF to amend their existing conditional registrations that contain expiration dates of November 9, 2018, and December 20, 2018, respectively." On November 1, 2018, pursuant to its October 31 "registration decision," the EPA issued a conditional registration to Bayer for its "M1768 Herbicide," also known as XtendiMax. On November 2, 2018, the EPA issued a conditional registration to BASF for its "Engenia Herbicide." On November 5, 2018, the EPA issued a conditional registration to Corteva for its "DuPont FeXapan Herbicide."

In its October 31, 2018, decision to grant the conditional registrations, the EPA assessed the benefits and costs of OTT application of dicamba on DT soybeans and cotton. In making this assessment, the EPA had before it comments from state agencies, farm bureaus, trade associations, farmers, seed companies, crop consultants, non-governmental organizations, academic and commercial weed scientists, and various other individuals.

The EPA found two benefits resulting from OTT application of dicamba. First, dicamba “provides growers with an additional postemergence active ingredient to manage difficult to control broadleaf weeds during the crop growing season, particularly for those situations where herbicide-resistant biotypes, such as Palmer amaranth, may occur (and few alternatives are available).” Second, dicamba “provides a long-term benefit as a tool to delay resistance [to] other herbicides when used as part of a season-long weed management program that includes preemergence (residual) and postemergence (foliar) herbicides (along with rotations between different MOA [modes of action]).”

In a separate document prepared by the EPA Office of Pesticide Programs (“OPP document”) and dated the same day as the registration decision document, the EPA rejected two additional benefits that had been proposed by the registrants. First, the EPA refused to find that OTT application of dicamba to DT soybean and cotton provided a comparative advantage in increasing crop yields: “The Agency

finds that dicamba can control weeds that might lead to yield loss but did not find sufficient information to show it was more effective than other weed control programs in reducing yield loss due to weeds.” Second, the EPA refused to find that OTT dicamba was “a crucial part of maintaining a conservation tillage program.”

In its October 31 decision document, the EPA also listed the costs, or risks, of dicamba use, which it characterized as “impacts.” It first discussed in a single paragraph “[i]mpacts to non-dicamba tolerant soybean growers.” Citing a slideshow from Monsanto’s second quarter 2018 financial results, the EPA wrote that Monsanto had predicted that 40 million acres of DT soybeans would be planted in 2018. The EPA then inferred that 55 percent of the 2018 soybean crop would be non-DT and “may potentially be damaged by very low levels of off-target dicamba.” In the OPP document, the EPA elaborated that “[i]n general, exposure during the reproductive growth stages could result in reductions in yield . . . , but the Agency does not have information to quantify this claim.”

The EPA next mentioned in a single paragraph “[i]mpacts to growers of other dicamba sensitive crops.” It wrote, “Many other plants are sensitive to low levels of dicamba and are listed on the dicamba labels.” The EPA named a number of the dicamba-sensitive crops listed on the labels. It also noted that the labels list “about 250 weeds—annual and perennial broadleaf plants and trees— . . . some of

which are desirable in non-crop settings.” In its separate OPP document, the EPA wrote that “[t]he Agency does not know the extent of the damage to sensitive crops.”

Finally, the EPA noted in a single paragraph “[i]mpacts to the landscape.” It wrote, “In 2017 and 2018, state agencies received reports from growers about incidents alleging damage to trees and other non-crop plants . . . . Potential impacts could result in damage to shelterbelts and windbreaks, as well as desirable plants in public parks and spaces.”

In its decision authorizing additional two-year conditional registrations, the EPA imposed more restrictions on OTT application of dicamba herbicides to DT soybeans and cotton. The most important additional restrictions were: (1) application was permitted only between one hour after sunrise and two hours before sunset (rather than any time between sunrise and sunset); (2) only two OTT applications were permitted per crop for soybeans, with the last application made no later than forty-five days after planting; (3) only two OTT applications were permitted per crop for cotton, with the last application made no later than sixty days after planting; (4) an omnidirectional, in-field fifty-seven-foot buffer was required in certain counties to protect listed plant species; and (5) applications could be made only by certified applicators.

## II. Procedural History

Petitioners previously filed a petition for review of the EPA’s 2016 registration decision for XtendiMax. Monsanto filed a motion to intervene, which we granted. Following the October 2017 label amendments, petitioners filed a motion to amend their petition for review, which we also granted. We held oral argument on August 29, 2018.

The EPA’s October 31, 2018, decision to grant additional, conditional two-year registrations for XtendiMax, Engenia, and FeXapan was published before we issued an opinion. We therefore held petitioners’ challenge moot, as the 2016 registration decision no longer had any legal effect. We held that petitioners’ challenge was not “capable of repetition but evading review” because there was no reasonable expectation that petitioners would be subject to the same action—the 2016 registration decision—again. *See Pub. Utils. Comm’n v. FERC*, 100 F.3d 1451, 1459–60 (9th Cir. 1996). We therefore dismissed the petition.

Petitioners filed a new petition for review on January 11, 2019, challenging the EPA’s October 31, 2018, decision. Monsanto again filed a motion to intervene, which we granted. We directed the Clerk of the Court to set an expedited briefing schedule. We held oral argument on April 21, 2020.

### III. Jurisdiction

FIFRA provides for review in the courts of appeals “as to the validity of any order issued by the Administrator following a public hearing” by “any person who will be adversely affected by such order and who had been a party to the proceedings.” 7 U.S.C. § 136n(b). A petition for review must be filed within sixty days of the entry of a challenged order. *Id.* “Unless the Administrator otherwise explicitly provides in a particular order, . . . the . . . date of entry of an order issued by the Administrator following a public hearing . . . shall be . . . on the date that is two weeks after it is signed.” 40 C.F.R. § 23.6.

The Administrator signed the EPA’s decision document on October 31, 2018. Petitioners filed their petition for review within two weeks and sixty days of that date, on January 11, 2019. Intervenor Monsanto argues that we lack jurisdiction, contending that the petition was filed too late. The EPA does not join Monsanto’s argument.

Monsanto contends that because the XtendiMax registration was “issued” and its Master Label marked “accepted” on November 1, 2018, that date constitutes the “date of entry,” making the EPA’s decision immediately reviewable and the petition therefore untimely. We disagree. Neither the November 1 registration nor the November 1 Master Label acceptance “explicitly provides” that the “date of entry” of the EPA’s order has been altered. We therefore conclude that the petition for review was timely filed and that we have jurisdiction.

#### IV. Scope of Petitioners' Challenge

Petitioners challenge the EPA's October 31, 2018, decision to conditionally amend the registrations of XtendiMax, Engenia, and FeXapan, permitting the OTT use of dicamba on DT soybeans and cotton for another two years. The scope of petitioners' challenge is stated in the first sentence of their brief: "This petition seeks review of the October 31, 2018 decision by the United States Environmental Protection Agency (EPA) to continue the new uses registrations of the pesticide dicamba on dicamba-resistant cotton and soybean[.]"

The EPA, however, asserts that petitioners have challenged only the registration of XtendiMax. It writes in its brief in a footnote: "Although not at issue here, EPA has issued registrations for two other dicamba products for the same uses, Engenia and FeXapan. . . . EPA's 2018 registration action also amended the Engenia and FeXapan registrations." The EPA made no argument in its brief in support of its contention that only the registration of XtendiMax is at issue. We could have held that the EPA's failure to make an argument in support of its assertion waived the argument. *See Aramark Facility Servs. v. Serv. Emps. Int'l Union*, 530 F.3d 817, 824 n.2 (9th Cir. 2008) (holding that arguments made in passing and inadequately briefed are waived). However, out of an abundance of caution and in recognition of the significant practical importance of the question, we asked for supplemental briefing from the parties and intervenor Monsanto.

In their petition for review, filed January 11, 2019, petitioners challenged an “order . . . announced in a document signed on October 31, 2018.” They attached as their sole exhibit the EPA’s October 31 decision, which they argued was “intertwined with and extended two earlier registration decisions by EPA over this same pesticide product,” referring to the EPA’s 2016 registration decision and the 2017 label amendment decision. Their opening brief before this court is consistent with their petition.

The EPA’s October 31, 2018, decision to register the three dicamba herbicides for OTT application qualifies as an “order” issued by the EPA. *See* 7 U.S.C. § 136n(b); *Pollinator Stewardship Council v. EPA*, 806 F.3d 520, 528 (9th Cir. 2015) (reviewing “the EPA’s *decision to . . . register*” a new insecticide) (emphasis added); *cf.* 7 U.S.C. § 136n(a) (conferring jurisdiction in the district court for “final actions of the Administrator not committed to the discretion of the Administrator by law”). For our court to have jurisdiction, the EPA’s decision must also follow a “public hearing.” 7 U.S.C. § 136n(b). We conclude that the 2018 registration decision was issued by the EPA “following a public hearing,” as the decision arises from a notice-and-comment period held prior to the related 2016 registration decision. We have construed the term “public hearing” broadly, holding that it merely “identifies elements essential in any fair proceeding—notice . . . given of a decision to be made and presentation to the



decisionmaker of the positions of those to be affected by the decision. By itself, the term does not connote more.” *United Farm Workers of Am. v. EPA*, 592 F.3d 1080, 1082 (9th Cir. 2010). Accordingly, we have held that “a ‘hearing’ includes proceedings in which there is no presentation of public argument.” *Id.* The EPA’s previous 2016 registration decision followed a “public hearing,” as conceded by the EPA and Monsanto.

The EPA and Monsanto make two unconvincing arguments for a restricted scope of review. First, they both argue that the other two registrants—Corteva and BASF—were not given fair notice of the petition, citing Federal Rule of Appellate Procedure 15(a)(2)(C). They cite as support for their argument the fact that only Monsanto has intervened. It is true that the Corteva and BASF have not intervened. But that does not change the nature of petitioners’ challenge to the EPA’s October 31, 2018, registration decision. As even Monsanto admitted in its supplemental brief to us, while the “petition for review did not mention the Engenia or FeXapan registration orders[,] [s]trictly speaking, it did not mention the XtendiMax registration order either.”

Second, the EPA argues that petitioners’ challenge cannot include FeXapan and Engenia because “[t]hese other registrations have administrative records that may overlap with, but are distinct from the administrative record for XtendiMax.” However, the administrative record produced by the EPA includes materials

concerning all three products. Comments in the record pertain to all three herbicides, with the EPA listing “general comments” in favor of and in opposition to “OTT *registrations* of dicamba.” Most important, the registration decision, including its risk assessments and cost-benefit analysis, concerned OTT dicamba products generally and was not registrant-specific. Indeed, the EPA’s decision document specifies that “[t]hree registrations . . . are impacted by this decision.”

Petitioners directly challenged the EPA’s entire October 31, 2018, registration decision. The EPA’s subsequent registrations of the three herbicides followed within days of its October 31 decision and were premised on that decision. We conclude that all three registrations are at issue in the petition before us.

## V. Standard of Review

We will sustain the EPA’s 2018 registration decision under FIFRA “if it is supported by substantial evidence when considered on the record as a whole.” 7 U.S.C. § 136n(b). The substantial evidence standard requires that we “affirm the EPA’s finding where there is such relevant evidence as a reasonable mind might accept as adequate to support a conclusion even if it is possible to draw two inconsistent conclusions from the evidence.” *Nat. Res. Def. Council v. EPA*, 857 F.3d 1030, 1036 (9th Cir. 2017) (internal quotation marks omitted). We “give due deference to EPA’s findings,” but may uphold its decision only “on the basis

articulated by the agency itself.” *Nat. Res. Def. Council v. EPA*, 735 F.3d 873, 877 (9th Cir. 2013).

## VI. Discussion

FIFRA regulates pesticide (including herbicide) use, sales, and labeling. 7 U.S.C. §§ 136–136y. The statute is administered by the EPA, with states given primary enforcement responsibility for pesticide use violations. *Id.* §§ 136a(a), 136w–1; *see Taylor AG Indus. v. Pure-Gro*, 54 F.3d 555, 559 (9th Cir. 1995). “FIFRA uses a cost-benefit analysis to ensure that there is no unreasonable risk created for people or the environment from a pesticide.” *Pollinator Stewardship Council*, 806 F.3d at 522–23 (internal quotation marks omitted).

The EPA wrote in its October 31, 2018, decision that it was taking action under Section 3(c)(7)(B) of FIFRA when it approved the registrations for XtendiMax, Engenia, and FeXapan. *See* 7 U.S.C. § 136a(c)(7)(B). That section authorizes the Administrator of the EPA to “conditionally amend” the registration of a pesticide to allow for new uses. *Id.* Section 136a(c)(7)(B) provides in relevant part:

The Administrator may conditionally amend the registration of a pesticide to permit additional uses of such pesticide notwithstanding that data concerning the pesticide may be insufficient to support an unconditional amendment, if the Administrator determines that (i) the applicant has submitted satisfactory data pertaining to the proposed additional use, and (ii) amending the registration in the manner

proposed by the applicant would not significantly increase the risk of any unreasonable adverse effect on the environment.

An “unreasonable adverse effect on the environment” includes “any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide.” *Id.* § 136(bb).

We consider in turn the two requirements for conditional amendments under § 136a(c)(7)(B): determinations that (i) the applicant has submitted “satisfactory data,” and (ii) the amendment will not “significantly increase the risk of any unreasonable adverse effect on the environment.” We conclude that substantial evidence does not support the EPA’s conclusion that both statutory prerequisites were satisfied.

#### A. “Satisfactory Data” Submitted by the Applicant

We begin by considering whether substantial evidence supported the EPA’s conclusion that the “applicant has submitted satisfactory data pertaining to the proposed” conditional registrations. The EPA suggests that these “data” include registrant-submitted studies, the broader universe of academic studies and datasets, and incident reports. We accept for present purposes the EPA’s interpretation of the term “data.”

##### 1. Monsanto’s Studies

In support of its 2018 application, Monsanto submitted the results of several of its own field studies evaluating XtendiMax. Some of the studies had been submitted in support of Monsanto's application for conditional registration in 2016. Some of the studies were new. All of the studies were described in a "white paper" Monsanto submitted to the EPA in support of its 2018 application.

a. Field Studies in Support of the 2016 Registration

Monsanto conducted its own studies of its reformulated dicamba herbicide prior to its application for conditional registration in 2016. Monsanto did not at that time make its herbicide available for independent studies. On a 3.4-acre field in Georgia and a 9.6-acre field in Texas, Monsanto tested XtendiMax (with "VaporGrip Technology") as well as M-1691, a dicamba-based formulation less volatile than older dicamba herbicides but lacking "VaporGrip Technology." In its 2018 white paper, Monsanto described these studies as having "tested real-world volatility potential" of XtendiMax. Based in part on results of these tests, as reported by Monsanto, the EPA granted the first two-year conditional registration for OTT dicamba, concluding that the benefits of its application to DT soybeans and cotton outweighed any risks because the label restrictions were "expected to eliminate any offsite exposures and effectively prevent risk potential to people and non-target species." As described above, and as the EPA later acknowledged, the EPA's conclusion was incorrect.

b. Field Studies in Support of the 2018 Registration

In support of its 2018 application, Monsanto conducted five additional studies measuring the volatility of XtendiMax. In its white paper, Monsanto described these studies as “confirm[ing] information provided prior to 2016.” The “information provided prior to 2016” included, of course, the studies submitted by Monsanto in support of its 2016 application. Relying in part on those studies, the EPA had mistakenly concluded that OTT application of XtendiMax created “minimal risks, if they exist at all.” Monsanto further described the new studies as “mimic[king] many ‘real world’ commercial applications and captur[ing] the full range of potential conditions that might cause volatility.”

The first additional study was conducted in October 2016 in Texas on a bare 4.6-acre field, and a post-emergent 9.1-acre DT cotton field. The second study was conducted in December 2017 on a post-emergent thirty-seven-acre soybean field in Australia. The third study was conducted in May 2018 on a post-emergent twenty-six-acre soybean field in Arizona. The fourth study was conducted in May and June 2018 on a post-emergent, nine-acre DT soybean field in Missouri. The fifth study was conducted in June and July 2018 on a post-emergent one-hundred-acre soybean field in Nebraska. All five studies measured air samples to determine the flux rate of volatilized dicamba. (Flux rate is a measurement of volatilized dicamba during a specific time period.) In its white paper, Monsanto described

each of the five studies as concluding that “[t]he highest peak flux rate [was] . . . consistent with peak flux values from the Texas and Georgia studies submitted prior to the 2016 XtendiMax registration.”

Monsanto also conducted a spray drift study in conjunction with its volatility study on the Arizona soybean field. It reported the result of its study as “consistent with and confirmatory of . . . EPA’s 2016 determination that no spray drift would occur outside of the 110-ft. buffer area in amounts that could have an effect on plant height.”

## 2. Telephone Reports to Monsanto

Monsanto reported in its white paper that it had received “hundreds of telephone calls regarding alleged off target movement” of dicamba during the 2017 and 2018 growing seasons. Monsanto reported that by July 19, 2017, it had received 1,002 calls. Monsanto reported that as of the same date on 2018 it had received 468 calls. Of the 468 calls in 2018, herbicide applicators had made 172 calls, and “non-applicators” had made 296. Monsanto reported that it had evaluated 450 of the calls. Monsanto concluded that XtendiMax was never, or almost never, at fault. It wrote, “XtendiMax volatility caused few *if any* incidents of off-target movement. Indeed, Monsanto has identified only eight incidents (less than 1%) where volatility even possibly could have been the cause—and none of

those were confirmed to be caused by volatility as all eight incidents had other potential causes as well.” (Emphasis in original.)

Monsanto absolved XtendiMax based primarily on the fact that many of the fields with alleged dicamba damage were located fifty to one hundred feet away from corn fields. Monsanto speculated that other herbicides, such as older formulations of dicamba, had been used on the corn fields and had drifted onto adjacent non-DT soybean fields. This explanation, however, is not supported by the data.

Older, non-XtendiMax dicamba has been used on post-emergent corn fields for decades, and complaints of dicamba damage to adjacent crops had been consistently low. Monsanto needed to explain why, if herbicide use on corn fields was at fault, the number of herbicide drift complaints had skyrocketed in 2017 and 2018, after XtendiMax, Engenia, and FeXapan were registered for post-emergent use. Monsanto theorized, without supporting evidence, that because of the increased publicity surrounding the new dicamba formulations, the applicators and farmers who complained of dicamba damage were “noticing—and reporting for the first time—effects that likely have been present for years.” There is no indication in the white paper that Monsanto ever sought to confirm its theory by asking growers on the adjacent corn fields whether, when, and in what manner, they might have used dicamba. Moreover, a 2014 U.S. Department of Agriculture report



indicates that use of the older formulations of dicamba on corn had been falling in recent years, as corn growers turned to newer herbicides. Between 1993 and 1997, dicamba had been used on between 21 and 29 percent of corn acreage; in 2012, it was used on only about 12 percent of corn acreage.

### 3. Other Field Studies

In making its 2018 registration decision, the EPA also considered data from research conducted by the University of Arkansas, the University of Wisconsin-Madison, Purdue University, Michigan State University, and the University of Nebraska. These studies were designed to evaluate spray drift and volatility of dicamba when applied to fields of ten to forty acres. The EPA also looked at a series of small-scale field studies (0.17 to 3.5 acres) conducted in Arkansas, Indiana, Missouri, Nebraska, and Tennessee. Studies in both the larger-scale and small-scale settings assessed both Engenia and XtendiMax. (XtendiMax and FeXapan involve the same form of dicamba and both have “VaporGrip Technology.”) From the field data, the EPA concluded that even the newer dicamba formulations could volatilize and drift, resulting in visual injury to plants.

### 4. Summary

The applicant data before the EPA ahead of the 2018 conditional registrations consisted in part of studies that Monsanto characterizes as merely confirming data used to support the 2016 registrations. The 2016 registrations, of

course, resulted in millions of acres of reported dicamba damage. But we need not decide whether substantial evidence supports the EPA’s conclusion that “satisfactory data” had been submitted. *See* 7 U.S.C. § 136a(c)(7)(B)(i) (requiring that the “applicant . . . submit[] satisfactory data pertaining to the proposed additional use”). FIFRA requires both “satisfactory data” *and* a finding that amendment of the registration will not “significantly increase the risk of any unreasonable adverse effect on the environment.” *Id.* § 136a(c)(7)(B)(i)–(ii). We turn now to this second requirement and conclude that the EPA’s determination that the requirement was satisfied is not supported by substantial evidence.

B. Whether Amendment “Significantly Increase[s] the Risk of Any Unreasonable Adverse Effect on the Environment”

To approve a conditional amendment of a registration for an already registered pesticide, the Administrator of the EPA must find under FIFRA that the amendment “would not significantly increase the risk of any unreasonable adverse effect on the environment.” *Id.* Such effects include “any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use any pesticide.” *Id.* § 136(bb). In its October 31, 2018, decision document, the EPA concluded “that extending the OTT use of dicamba for two years on dicamba-tolerant cotton and dicamba-tolerant

soybeans in the manner authorized under this decision will not cause unreasonable adverse effects on the environment.”

As described above, the EPA found two benefits resulting from the 2018 registrations—providing soybean and cotton growers an additional tool for managing difficult-to-control weeds, and delaying weed resistance to other herbicides. Ample evidence supports these two findings. Notably, however, the EPA in 2018 refused to find as a benefit that OTT application of dicamba herbicides increased crop yields by comparison to application of other herbicides.

Against those two benefits, the EPA balanced the risks, which it characterized as “impacts.” It divided those impacts into three categories—impacts to non-DT soybean growers; impacts to growers of other dicamba-sensitive crops; and impacts to the “landscape.”

A review of the record shows that the EPA substantially understated the risks that it acknowledged. The review also shows that the EPA entirely failed to acknowledge other risks.

#### 1. Understatement of Acknowledged Risks

In both the registration decision document signed on October 31 and the OPP document dated the same day, the EPA substantially understated the risks to non-DT plants by OTT application of dicamba herbicides.

##### a. DT Seed Acreage

First, the EPA understated the DT seed acreage that had been planted in 2018, and therefore the amount of dicamba herbicide that had been applied to post-emergent crops that year. The EPA relied on a Monsanto prediction that 40 million acres of its DT soybeans would be planted in 2018. This reliance was improper. The EPA's decision document was signed on October 31, at the end of the growing season. By then, the EPA was in a position to know the actual acreage of DT seeds that had been planted. In its white paper, Monsanto had written that 56 million acres of its DT seeds had been planted in 2018. It did not specify what share came from DT soybeans and what share came from DT cotton. But the record elsewhere indicated that DT soybeans comprised as many as 50 million of those acres. In other words, the EPA underestimated by as much as 25 percent the amount of DT soybeans planted and, commensurately, the amount of dicamba herbicides applied in 2018.

b. Under-Reporting or Over-Reporting of Dicamba Damage

Second, the EPA's conclusion that complaints to state departments of agriculture of dicamba damage could have either under-reported or over-reported the actual amount of damage is not supported by substantial evidence. The record clearly shows that complaints understated the amount of dicamba damage.

A graph included in the EPA's decision document shows complaints made to state agriculture departments in sixteen of the thirty-four states in which OTT application of dicamba was authorized. The graph covers the period from 2013 through 2018 and includes all complaints of herbicide drift, not limited to dicamba. According to the graph, herbicide drift complaints consistently averaged slightly fewer than 1,000 per year from 2013 through 2015. The number of complaints rose to a little under 1,250 during 2016—the year DT soybeans and cotton became available for planting and were reportedly sprayed with dicamba herbicides not approved for OTT use. In 2017, the first year that OTT application of dicamba was allowed, there were more than 3,000 drift complaints. In 2018, there were more than 2,250 such complaints.

The EPA has no explanation for the spike in complaints in 2017 and 2018 other than the new conditional registration of dicamba for OTT application. The EPA minimized the significance of the increase in complaints by crediting a view that the number of complaints could reflect an over-reporting of damage. It wrote in its registration decision that many industry stakeholders believed that the number of complaints under-reported the amount of dicamba-caused damage, but that “others” believed instead that the complaints over-reported the amount of damage:

According to the AAPCO [the Association of American Pesticide Control Officials], university researchers, and some growers, the number of cases reported to state agencies may be substantially lower than the actual incidents . . . observed in the field . . . . *Others* believe that there may be issues of overreporting.

(Emphasis added.) The EPA wrote to the same effect in its OPP document, “The number of incidents may not accurately represent the extent of dicamba-related damage; incidents may be under- or over-reported.”

The EPA did not specify in the text of its registration decision who the “others” (plural) were. However, it appended to the text a footnote citing only the Monsanto white paper. That is, Monsanto, and only Monsanto, was the “others.” As noted above, Monsanto wrote in its white paper that it had concluded that none, or almost none, of the damage reported in the 450 telephone calls it had evaluated in 2018 had been caused by the newly registered dicamba herbicides. Monsanto speculated that the damage was largely caused by other herbicides, including the older formulations of dicamba, applied on nearby corn fields; speculated that the professional applicators and farmers who called complaining of dicamba damage had had such damage in prior years; and speculated that the callers either had not noticed the damage previously or had not attributed it to dicamba. (Recall that dicamba use on corn had been decreasing in recent years, and that dicamba damage is easily detected by its signature “leaf cupping” on affected plants.)

The EPA's purported agnosticism as to whether dicamba damage was under- or over-reported is contradicted by overwhelming record evidence that dicamba damage was substantially under-reported. For example, during the summer of 2018, Professor Robert Hartzler at Iowa State University ("ISU") conducted a survey of university field agronomists that was forwarded to Baris of the EPA. Hartzler recounted: "We know the reported incidences represent a very small fraction of total drift cases as farmers are reluctant to involve regulatory agencies. The majority of ISU Extension and Outreach agronomists reported that Iowa Department of Agriculture and Land Stewardship (IDALS) was contacted in less than 25% of the dicamba cases, and nobody reported IDALS was contacted in the majority of cases." In a September 2017 article in the record from the *Progressive Farmer*, Carrie Leach, Quality Assurance Director for the Office of Indiana State Chemist, estimated that only one out of ten farmers affected by dicamba injury actually filed formal complaints with her office. In September 2018, before the EPA issued its decision document, Baris himself gave a PowerPoint presentation in which he admitted, "Not all reports of crop damage were reported to State Departments of Agriculture." If complaints to state departments of agriculture under-reported dicamba damage, the amount of actual dicamba damage was, of course, even greater than what the graph in the EPA's 2018 decision document captured.

c. Failure to Quantify or Estimate Dicamba Damage

Third, the EPA refused to quantify or estimate the amount of damage caused by OTT application of dicamba herbicides, or even to admit that there was any damage at all. When referring to dicamba damage to non-DT soybeans, the EPA wrote in its 2018 decision document only that such soybeans “may *potentially* be damaged.” (Emphasis added.) In the accompanying OPP document, it wrote with respect to such soybeans, “In general, exposure during the reproductive growth stages *could result* in reductions in yield . . . , *but the Agency does not have information to quantify this claim.*” (Emphasis added.) When referring to other non-DT crops, the EPA identified a number of such crops by name, but did not write that any had been damaged by dicamba. When referring to dicamba-caused damage to the “landscape,” it wrote only of “incidents *alleging* damage” and of “[p]otential impacts [that] *could result* in damage.” (Emphasis added.)

The EPA had information from which it could have quantified dicamba damage, even if it could not have calculated with precision the reduction in yield caused by the damage. For example, Baris had conceded in his September 2018 PowerPoint presentation that in 2017 “more than 3.6 million” acres of non-DT soybeans had been damaged by dicamba. Indeed, in its 2018 registration decision, the EPA itself referred to the 3.6 million figure. Bradley of the University of Missouri, the source of the 3.6 million figure, had reported that by mid-July 2018,



approximately 1.1 million acres of non-DT soybeans had already been damaged in eighteen states.

The EPA also had a great deal of qualitative information about extensive dicamba damage during both 2017 and 2018. We focus here only on the damage reported in 2018. In comments forwarded by email to Baris, Bradley wrote that as of June 1, “university weed scientists and state Department of Agriculture representatives” had reported dicamba injury to “specialty crops, vegetable, and ornamental, fruit, and shade trees.” Dr. Ford Baldwin of Practical Weed Consultants, LLC in Arkansas wrote in a letter forwarded to Baris on June 25, “Once again in 2018, large acreages of non-dicamba-tolerant soybeans in eastern Arkansas are affected by this herbicide as well as many vegetables. In addition, most trees in the countryside and towns are cupping and even dying following multiple years of exposure.” In a *Farm Progress* news article on June 26, Bradley is quoted as saying, with respect to dicamba damage in the “bootheel” of Missouri, “From what I can tell, . . . if you don’t have Xtend soybean, your crop is going to be cupped from one end to the other. That’s not a surprise because we’ve seen that for the past two seasons.”

In a July 2 email forwarded to Baris, Duane Simon, a Supervisor at the Kansas Department of Agriculture, wrote, “So you know, for the last two weeks we have been over run with dicamba complaints in Kansas. Most of them have

been on the Eastern side of the state.” Andrew Thostenson, a pesticide program specialist at North Dakota State University, wrote in a July 23 email to Baris, “What we now know, in 2018, is that minimizing off target movement of dicamba to a reasonable level is NOT possible. If you take 2017[] off the board, and only look at what has happened in 2018, I think this level of movement is completely unacceptable.” A July 20 article in DTN’s *Progressive Farmer*, forwarded to an EPA official on July 25, reported extensive dicamba damage. Damage suffered by Mike Hayes, a Tennessee resort owner, was one of many examples: “Last year, Hayes experienced wave after wave of dicamba exposure. It wiped out the resort’s garden—which supplies the on-site restaurant—three times before Hayes gave up. He estimates it killed 20% of the young trees he planted . . . . This year, he estimates he has been hit eight separate times by dicamba. He expects five cypress trees to die this year . . . .”

In an August 8 article in *Delta Farm Press*, Professor Larry Steckel of the University of Tennessee wrote, “[T]he drift we . . . saw this June and July in Tennessee with dicamba in the new use pattern in Xtend crops is like nothing I have ever seen before. I have never seen a herbicide that has so easily and frequently slipped the leash. Nor have I seen a herbicide that, once off the leash, would roam so far. Dicamba drift for the past three years has often travelled a half mile to three-quarters of a mile and, all too frequently, well beyond that. . . . My

best estimate is that Tennessee has roughly 100,000 acres of non-dicamba tolerant soybeans planted and about 40 percent of them are currently showing dicamba injury.” Hartzler of ISU wrote in August 15 of his survey of ISU field agronomists: “Half of the agronomists stated the number of soybean acres damaged by dicamba was similar to 2017, whereas the remainder were split between fewer acres and more acres damaged in 2018 than 2017. When I’ve asked commercial agronomists the same question, the range of responses was similar to those of my extension colleagues.”

## 2. Failure to Acknowledge Risks

The EPA not only substantially understated the risks it acknowledged, as just described. It also entirely failed to acknowledge other risks, including those it was statutorily required to consider, as we describe below.

### a. Substantial Non-Compliance with Label Restrictions

Extensive evidence in the record indicates that there is a risk of substantial non-compliance with the EPA-mandated label for the 2019 and 2020 growing seasons. Non-compliance with the restrictions, of course, will result in dicamba damage. The EPA entirely failed to acknowledge this risk.

As detailed above, there have been three sets of EPA-mandated label restrictions for OTT use of XtendiMax, Engenia, and FeXapan. The initial set was for the 2017 growing season, after the herbicides were first conditionally

registered; the second was for the 2018 growing season, after the herbicide manufacturers “volunteered” to amend the label; and the third was for the 2019 and 2020 growing seasons, after the conditional registrations were extended for two years. The labels became increasingly restrictive and, correspondingly, more difficult to follow.

The 2018 label, for use during the 2019 and 2020 growing seasons, is hardly a “label” as that term is usually understood. It is forty pages long, with myriad instructions and restrictions. The 2018 label provides, inter alia, (1) application is permitted only between one hour after sunrise and two hours before sunset; (2) application is prohibited if the wind speed is below three miles per hour or above ten miles per hour; (3) application is prohibited during temperature inversions; (4) application is prohibited if rain resulting in soil runoff is expected in the following twenty-four hours; (5) application is prohibited when the wind is blowing toward “adjacent” non-DT soybean and cotton, as well as other dicamba-sensitive crops; (6) there must be an in-field, downwind buffer of at least 110 feet; (7) in certain counties, there must be an omnidirectional fifty-seven-foot in-field buffer; (8) spraying equipment may not exceed a ground speed of fifteen miles per hour; (9) the spray boom can be no more than twenty-four inches above the target weed or the crop canopy; (10) for DT soybeans, only two applications per crop are permitted, with the last application no later than forty-five days after planting; (11)

for DT cotton, only two applications per crop are permitted, with the last application no later than sixty days after planting; and (12) all applicators must be certified and have dicamba-specific training.

Even before the additional restrictions were added to the 2018 label, many industry professionals had been dismayed by the difficulty in complying with the complex and onerous label requirements. By October 2018, there was substantial evidence that even conscientious applicators had not been able consistently to adhere to the label requirements.

Dave Coppess, an executive vice president at HeartLand Co-op in Iowa, was interviewed for an April 17, 2018, article in *Agribusiness Global*. The article appeared in Baris' Google Alert for "dicamba," and otherwise would have been accessible to him. Coppess said of the label that had been in place for the 2017 growing season, "This was probably the most complex label I had ever seen in my 40-year career . . . ." "Last year, our sales manager calculated that based on the [2017] label, we only had 44 hours of application time that our rigs would have been on label. That's the old label. Now, the new label is going to be even more restrictive . . . ."

A question submitted to Keigwin of the EPA in April 2018 by an attendee of a dicamba webinar for the Agricultural Retailers Association asked, "There doesn't appear to be any way for an applicator to be 100% legal in their application. What

is an applicator to do in this no-win situation?” Brian Major, a grain producer in Fulton County, Kentucky, wrote in an August 15, 2018, email to Keigwin, describing a DT soybean field surrounded by non-DT crops: “[T]here is no legal way to spray this field. You can’t apply dicamba with a wind speed of 0 MPH (must be 3-10 MPH) and you can’t apply it when the wind is blowing towards a sensitive crop. So there is really no way to use the products.” He continued: “We here in west Kentucky are also seeing a lackadaisical approach from the Ky Dept of Agriculture on enforcement of the label, the fines for label violation are viewed among the violators ‘as the cost of doing business’ or ‘it’s cheaper to pay the fine than lose yield by not spraying.”” An August 21, 2018, National Public Radio interview with a vineyard owner, circulated as an attachment to an internal EPA email, reported: “Longtime winemaker Bobby Cox says a 10-mph day in blustery West Texas is basically a fairy tale. ‘You can’t do it,’ he says, laughing uproariously. ‘Your fairy godmother has to pull out a wand, tap the pumpkin and turn it into a carriage.’”

In a July 20, 2018, article in a Purdue University newsletter forwarded by Baris to his EPA colleagues, Purdue Professor Bill Johnson and Weed Science Program Specialist Joe Ikley calculated the difficulty in complying with the 2017 label during the 2018 growing season. They ignored the label’s prohibition on application when rain is forecast in the next twenty-four hours, instead relying on

actual rainfall events. Taking into account the restrictions based on wind speed and temperature inversions, they calculated for a location near Purdue's Indiana agriculture station that there were only forty-seven hours in the entire month of June 2018 during which OTT application of dicamba would have been legal.

There were only two days of the month in which application during an eight-hour day would have been possible—eleven hours during one day, and eight hours during another. The remaining hours were scattered throughout the rest of the month: one hour (one day); two hours (one day); three hours (three days), five hours (two days); six hours (one day). Johnson and Ikley concluded that the data “reinforces the fact that we do not have very many hours in the real world where we can be completely compliant with the restrictions on the new dicamba product labels.” Based in part on this data, the Office of Indiana State Chemist observed that “the 2017 and 2018 dicamba label directions have been extremely challenging for a trained applicator to comply with completely.”

The Illinois Fertilizer and Chemical Association conducted a survey of its members in July and August 2018. One question was: “As a commercial applicator, do you feel that your operators were able to follow the dicamba product label effectively this year?” Approximately 66 percent of the respondents answered “yes”; approximately 28 percent answered “most of the time”; and approximately 6 percent answered “no.” Comments appended to the survey results

included: “Conditions that allow for a technically legal application is very small”; “Weather is never right. Too windy, too hot, to[o] humid—we can’t win”; “Very light, shifting winds made it impossible to ‘always be right’ during the time when we needed to spray”; and “I believe it is impossible to make an on-label application as the label is written . . . .”

The comments, emails, and news articles received by the EPA were directed to the labels in place for the 2017 and 2018 growing years—the period leading up to the EPA’s 2018 registration decision challenged here. As described above, the EPA added even more restrictions in October 2018. Two changes are particularly noteworthy. First, during 2018, OTT application of dicamba to DT soybeans and cotton was legal from sunrise to sundown. During 2019 and 2020, the application period will be reduced by three hours every day, now running from one hour after sunrise to two hours before sunset. Second, in 2018, there was no days-after-planting prohibition. In 2019 and 2020, farmers will have to apply OTT dicamba within sixty days of planting DT cotton, and within forty-five days of planting DT soybeans. Many applicators found it difficult or impossible to comply with the 2017 label during the 2018 growing season. Compliance with the 2018 label during the 2019 and 2020 growing seasons will be even more difficult.

In its October 31, 2018, decision approving OTT use of dicamba on DT soybeans and cotton, the EPA nowhere acknowledged the evidence in the record



showing there had been substantial difficulty in complying with the mitigation requirements of earlier labels. Nor did it acknowledge the likelihood that the additional mitigation requirements imposed by the 2018 label would increase the degree of non-compliance.

b. “Economic, Social, and Environmental Costs”

FIFRA requires the EPA to consider, as part of a cost-benefit analysis, “any unreasonable risk to man or the environment, *taking into account the economic, social, and environmental costs* and benefits of the use of any pesticide.” 7 U.S.C. § 136(bb) (emphasis added). The EPA entirely failed to acknowledge risks of economic and social costs.

1. Economic Cost

The EPA entirely failed to acknowledge an economic cost that is virtually certain to result from the conditional registrations of the dicamba herbicides for OTT application. The EPA knew that Monsanto’s glyphosate-resistance trait, and accompanying glyphosate herbicide, had achieved a near-monopoly. More than 90 percent of soybeans planted in 2008 were grown from patented glyphosate-tolerant seeds. Patented dicamba-tolerant seeds and the three new dicamba herbicides appear to be well on their way to the same degree of market dominance. By 2017, soybeans with Monsanto’s dicamba-tolerance trait comprised a quarter of U.S. soybeans, and more than 6 percent of all U.S. cropland. By 2018, Monsanto’s

dicamba-tolerance trait was in approximately 50 percent of U.S. soybeans. Use of the three dicamba herbicides has increased commensurately.

Many farmers have felt, and will continue to feel, compelled by the increased planting of DT soybeans, and the accompanying increased use of OTT dicamba, to change from non-DT to DT soybeans. Rob Robinson, CEO and owner of Rob-See-Co in Waterloo, Nebraska, wrote in a September 14, 2017, letter to the Administrator of the EPA, “[T]he amount of damage I am hearing about from my soybean seed customers and sales force is alarming. Even more alarming is the number of my customers who have told me they will plant all Xtend varieties, instead of my [non-DT] seed, as a defensive measure against damage from neighbors who will use Xtend varieties and spray the approved dicamba product. . . . I find this issue incredibly anticompetitive . . . .” Joe Merschman, president and CEO of Merschman Seeds, Inc. in West Point, Iowa, wrote in a September 25, 2018, email to Keigwin of the EPA, “This year we are hearing this statement over and over again from our farmer customers when it comes to planning their soybean seed purchases for 2019[:] ‘I guess I will have to plant dicamba resistant soybeans next year to avoid the off target injury. I cannot afford to keep getting my soybeans damaged from dicamba.’” Merschman wrote that market research from the Iowa-Illinois-Missouri area indicated that 59 percent of soybean acres were expected to be dicamba-tolerant in 2019. Sonny Beck, CEO of

the seed company Beck's Superior Hybrids, wrote to Keigwin on July 27, 2018, advocating that the new dicamba formulations be restricted to pre-plant use only even though he himself had sold more than one million bags of Xtend soybean seeds in 2018. Among his reasons, Beck cited concern that other seed technologies wouldn't get a chance to "make an impact on weed resistance," as farmers increasingly adopted DT seeds out of fear over dicamba drift.

Professor David Ripplinger of North Dakota State University recounted in a February 2018 article in *Agweek*, "The farmers I talk to are almost all going to grow dicamba soybeans this year because they don't want to be exposed to the risk." Steckel of the University of Tennessee recounted in his August 2018 article, "Many growers have told me they simply gave up trying to grow non-Xtend soybeans because they had repeatedly seen dicamba injury in past years—often multiple times in the same year." In his letter forwarded to the EPA in June 2018, Dr. Baldwin wrote, "Dicamba has a chemistry problem that likely cannot be fixed, or at least no evidence has been provided that it can be successfully applied. If it can, it will only be through advances in chemistry. As the technology currently exists, renewing the cotton and soybean registrations will leave the industry no choice but to plant 100% of the soybean acreage [with] this technology."

Extending the conditional registrations for OTT use of XtendiMax, Engenia, and FeXapan creates a substantial the risk that DT soybeans, and possibly DT

cotton, will achieve a monopoly or near-monopoly. The likely anti-competitive effect of the registrations would impose a clear economic cost, but the EPA at no point identified or took into account this cost.

## 2. Social Cost

The EPA also entirely failed to acknowledge a social cost that had already been experienced and was likely to increase. The record contains extensive evidence that OTT application of dicamba herbicides has torn apart the social fabric of many farming communities. Major, the Kentucky grain producer, wrote in his August 2018 email to Keigwin: “This used to be a pretty close area, with neighbors helping neighbors. This chemical has changed this for quite a few growers. The applicators of dicamba are damaging their neighbor’s crops and when they are asked about it the normal answer is, ‘You can’t prove it,’ or ‘I didn’t do it[.]’” The July 20, 2018, article in *Progressive Farmer* recounted, “The rise in off-target dicamba injury has strained the social fabric of rural communities, said University of Illinois weed scientist Aaron Hager. ‘It’s pitting neighbor against neighbor,’ he said. ‘Farmers threatening other farmers. I’ve never seen this before over the use of technology.’” The article recounted further, “[An] Illinois homeowner, who spoke on the condition of anonymity to protect her from reprisals in her community, has suffered severe damage to a wide variety of trees . . . as well as ornamental plants, shrubs and a vegetable garden.” Samples sent to a private

laboratory tested positive for dicamba. “‘These are 100-year old oaks,’ she said. ‘We’re senior citizens and we don’t have the time left in our lives to plant new trees and watch them get even halfway to maturity. . . . We are farmers, too . . . . We live in a rural area with generations of families that have been here for years and years. We’ve known them all our lives. But when we talk to the farmers, they don’t seem to care that much. There’s no apologies, no offers to help, nothing.’” In a comment to the Illinois Fertilizer and Chemical Association’s August 2018 survey, one respondent noted of dicamba use, “In 43 years of business I have never seen a more divisive product among neighbors both farm and non-farm.” Another respondent wrote, “This technology cannot continue as is if we ever wish to raise a susceptible crop or maintain healthy relationships with our residential and environmental neighbors.” A farmer in Arkansas was shot and killed in an argument over dicamba damage in 2016.

The severe strain on social relations in farming communities where the new dicamba herbicides are being applied is a clear social cost, but the EPA did not identify and take into account this cost.

### C. Substantial Evidence Does Not Support the EPA’s Decision

Considering the record as a whole, we conclude that substantial evidence does not support the EPA’s October 31, 2018, decision to grant conditional registrations to XtendiMax, Engenia, and FeXapan for OTT application on DT

soybeans and cotton. The EPA found two benefits from the uses, which were amply supported by evidence in the record. But the EPA failed to perform a proper analysis of the risks and resulting costs of the uses.

The EPA substantially understated the costs it acknowledged. The EPA substantially understated the acreage planted with DT soybeans in 2018 and the resulting use of dicamba in that year. It recounted in its decision document that Monsanto had “predicted” that 40 million acres of DT soybeans would be planted in 2018, even though record evidence then before the EPA indicated the actual DT soybean acreage was much higher and that the combined DT soybean and cotton acreage was higher still. Further, the EPA recognized that there had been an enormous increase in dicamba complaints in 2017 and 2018, but it purported to be agnostic as to whether those complaints under-reported or over-reported the amount of dicamba damage. In fact, record evidence shows that the complaints substantially under-reported the actual amount of damage. Finally, the EPA substantially understated the amount of dicamba damage during the 2017 and 2018 growing years, characterizing the damage as “potential” and “alleged,” and claiming there was insufficient data from which to estimate the amount of damage. In fact, record evidence shows that OTT application of dicamba herbicides in 2017 and 2018 had caused enormous and unprecedented damage.

The EPA also entirely failed to acknowledge other costs. The EPA entirely failed to acknowledge the substantial degree of non-compliance with the 2017 label, and the likelihood of an even greater degree of non-compliance with the 2018 label. Further, the EPA entirely failed to recognize the economic cost imposed by the coercion of non-DT farmers to convert to DT crops, and the resulting anti-competitive effect of that coercion. Finally, the EPA entirely failed to recognize the enormous social cost to farming communities where use of dicamba herbicides had turned farmer against farmer, and neighbor against neighbor.

#### VII. Post-Argument Request by Petitioners

On May 13, 2020, in the supplemental brief we had ordered pertaining to the scope of their challenge, petitioners requested (though without making a formal motion) that we issue a summary decision, to be followed by an opinion. The EPA moved for permission to file a supplemental brief opposing petitioners' request, as well as for judicial notice of an extra-record document. In light of our issuance of the opinion today, we deny the EPA's motions.

#### VIII. Remedy

The EPA and Monsanto urge us, if we conclude that substantial evidence does not support the 2018 conditional registrations, to remand without vacatur, leaving the conditional registrations in effect. We decline to do so.

We order remand without vacatur “only in limited circumstances.” *Pollinator Stewardship Council*, 806 F.3d at 532 (internal quotation marks omitted). To determine whether vacatur is appropriate, “we weigh the seriousness of the agency’s errors against the disruptive consequences of an interim change that may itself be changed.” *Id.* (internal quotation marks omitted). We also consider the extent to which either vacating or leaving the decision in place would risk environmental harm. *Id.* We have also “looked at whether the agency would likely be able to offer better reasoning or whether by complying with procedural rules, it could adopt the same rule on remand, or whether such fundamental flaws in the agency’s decision make it unlikely that the same rule would be adopted on remand.” *Id.*

Applying these criteria, we vacate the registrations. The EPA made multiple errors in granting the conditional registrations. As described above, the EPA substantially understated the risks it acknowledged, and it entirely failed to acknowledge other risks. We conclude that the “fundamental flaws” in the EPA’s analysis are so substantial that it is exceedingly “unlikely that the same rule would be adopted on remand.” *Id.*

We are aware of the practical effects of our decision. Among other things, we are aware of the adverse impact on growers who have already purchased DT soybean and cotton seeds and dicamba products for this year’s growing season,



relying on the availability of the herbicides for post-emergent use. As the EPA explained to us in its brief, arguing against vacatur: “Growers already have invested in both Xtendimax and accompanying resistant seeds for the 2020 growing season. Vacatur could leave those growers with an unusable pesticide technology system and force them to expend additional money on alternative seeds and pesticides.” The EPA had also cautioned in its 2018 decision to grant conditional registrations, “It is important to note that using registered dicamba products on dicamba-tolerant cotton or dicamba-tolerant soybean crops that are not registered specifically for post-emergence use on dicamba-tolerant cotton or dicamba-tolerant soybean crops is inconsistent with the pesticide’s labeling and a violation of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).” We acknowledge the difficulties these growers may have in finding effective and legal herbicides to protect their DT crops if we grant vacatur. They have been placed in this situation through no fault of their own. However, the absence of substantial evidence to support the EPA’s decision compels us to vacate the registrations.

Petition for review **GRANTED**. Registrations **VACATED**. The mandate shall issue forthwith.