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A Review of the Ecological Effects of Road Reconfiguration and Expansion on Coastal Wetland Ecosystems

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Introduction

The importance of coastal wetlands and estuaries to global biodiversity and ecosystem function is well known. In California, only a fraction of the historic extent of these wetlands remain, and it is only the protection afforded by laws such as the California Coastal Act that has reduced and sometimes reversed the loss. Even projects next to wetlands that do not directly involve filling of wetlands can have significant adverse ecological effects. The purpose of this review is to discuss the ecological consequences of expanding and rebuilding road systems within a wetland area. This review focuses on the potential adverse ecological effects of two projects before the California Coastal Commission on November 14, 2001 (Item W12.3/W12.5c and Item W12.5d/12.5e). It is also our intention that the scientific research assembled herein will provide a reference document for the Commission as it considers other similar projects under its jurisdiction.

Several topics pertaining to roads and road construction are discussed. First we consider the consequences of increased artificial night lighting on wetland ecosystems. Second, we discuss the impacts of noise on birds and other wildlife in wetland ecosystems. Third, we review some of the research about roadkill and road-induced fragmentation, and its potential impact on wildlife populations. Fourth, we address the impacts of increased road area on water quality and efficacy of detention basins in mitigating such impacts. Finally, we offer some particular observations unique to the two proposals under consideration.

Artificial Night Lighting

Illumination of the night sky has increased drastically over the past century. Today, more than two-thirds of the population of the United States lives in a location where the Milky Way is no longer visible at night.[1] Despite increasing knowledge about the effects of artificial lighting on human health, astronomical observation, and energy consumption, the ecological consequences of nighttime lighting is not widely known. Despite the lack of widespread incorporation of the effects of lighting into the environmental review process, significant scientific research has been completed that can and should guide policy decisions.

Road construction, expansion, or reconfiguration in the United States almost inevitably involves an increase in nighttime lighting. For road projects proposed by Playa Capital, lighting at the two sites is currently minimal. At the intersection of Culver Boulevard and Jefferson Boulevard only two streetlights are currently functioning (another two are installed, but not operational). At the intersection of Culver Boulevard and Lincoln Boulevard, only a few streetlights are installed under the Culver Boulevard bridge. Consequently, ambient nighttime lighting levels at these

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1. Cinzano, P., F. Falchi, and C.D. Elvidge. 2001. The first world atlas of artificial night sky brightness. *Monthly Notices of the Royal Astronomical Society* 000:1–16.

locations are low compared to the surrounding urban area. The undeveloped portions of the Ballona wetlands are the darkest areas in West Los Angeles. While the staff recommendations for both projects include a condition requiring the lowest possible lighting levels permissible under state and federal law, the projects are nevertheless likely to result in a significant increase in nighttime lighting levels experienced in the environmentally sensitive habitat areas of the Ballona wetlands.

Artificial night lighting can have significant effects on virtually all classes of terrestrial organism. We will discuss the mechanisms and potential results of some of these impacts.

Plants

Light is central to the function and physiology of plants. However, relatively little published information is available about the effects of artificial night lighting on plants in natural settings. One consequence of lighting is to change the duration of light and dark ("photoperiod") experienced by the plant. Many functions may be triggered by photoperiod, including seed germination,[2] flowering, and leaf loss. [3] Some plants will not flower if night length is not sufficiently long.[4] Trees under streetlights have been observed to retain leaves longer into the fall in temperate climates.[5] Disruption of plant growth by sodium vapor lights has been recorded in several studies.[6] These studies do not pertain to wetland plants specifically, but there is no reason to expect that wetlands species would not also be affected by artificial lighting in similar ways.

Aquatic Invertebrates

Artificial lighting affects aquatic invertebrates through modification of photoperiodic behaviors such mating and foraging. In the first experimental study on this topic, Dr. Marianne Moore found that the aquatic zooplankton *Daphnia* exhibited different behaviors in wetlands that had a natural photoperiod and those that were subject to artificial lighting.[7] She found that *Daphnia* in dark night conditions migrate farther up and down the water column to forage on algae than those exposed to higher ambient light levels. She documents that lakes in urban areas are exposed to over 100 times the light levels of rural lakes, and concludes that this will affect the foraging patterns of *Daphnia* across the lighting gradient. This, she states, is important, because

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2. Edwards, D.G.W., and Y.A. El-Kassaby. 1996. The effect of stratification and artificial light on the germination of mountain hemlock seeds. *Seed Science and Technology* 24:225–235.
3. Outen, A. 1998. *The possible ecological implications of artificial lighting*. Hertfordshire, UK: Hertfordshire Biological Records Centre.
4. Campbell, N.A. 1990. *Biology* (2nd ed.). New York: Benjamin Cummings Inc.
5. Environmental Buildling News. 1998. Light pollution: efforts to bring back the night sky. *Environmental Building News* 7(8).
6. Sinnadurai, S. 1981. High pressure sodium street lights affect crops in Ghana. *World Crops* (Nov/Dec):120–122. Cathey, H.M., and Campbell, L.E. 1975. Effectiveness of five vision-lighting sources on photoregulation of 22 species of ornamental plants. *J. Am. Soc. Hort. Sci* 100:65–71.
7. Moore, M.V., S.M. Pierce, H.M. Walsh, S.K. Kvalvik, and J.D. Lim 2000. Urban light pollution alters the diel vertical migration of Daphnia. *Proceedings of the International Society of Theoretical and Applied Limnology* in press. Pierce, S.M., and M.V. Moore 1998. Light pollution affects the diel vertical migration of freshwater zooplankton. Abstract, 1998 Annual Meeting of the Ecological Society of America, Baltimore, MD.

"vertical migration of lake grazers may contribute to enhanced concentrations of algae in both urban lakes and coastal waters. This condition, in turn, often results in deterioration of water quality (i.e. low dissolved oxygen, toxicity, and odor problems)."[8] If *Daphnia* or other zooplankton do not migrate to the surface of the wetland to forage on algae because light levels are too high, then the whole aquatic food chain is in jeopardy. Because the two projects under consideration are so close to existing wetlands, adverse impacts on aquatic invertebrates in this manner is a distinct possibility.

Terrestrial Invertebrates

Terrestrial invertebrates are similarly affected by artificial night lighting. Many larval forms of arthropods are positively phototactic (e.g., attracted to light, even artificial light).[9] Artificial lighting results in increased mortality of moths and other nocturnal insects.[10] While the most conspicuous and well-known examples are moths, many types of insects are attracted to artificial lights, including a wide range of orders that are known to be attracted to light sources including lacewings, beetles, bugs, caddisflies, crane flies, midges, hoverflies, wasps, and bush crickets.[11] Some insects are attracted to night lighting, while other nocturnal species are stimulated to rest under increased lighting levels as if it were dawn. Low pressure sodium lamps, which provide a yellow light, attract the fewest number of insects.[12] Lighting not only influences nighttime locomotory behavior but can also affect reproductive activities.[13]

While it may seem to be a benefit for diurnal species to be active under streetlights, any gains from increased activity time are offset by increased predation risk. In a study of butterfly larvae, a higher growth rate associated with longer photoperiod (as would be caused by artificial light) resulted in significantly higher predation on the butterfly larvae from the primary parasitoid species.[14] Some bat species are attracted to streetlights where they forage on the gathered

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8. Moore, M.V. 2001. Wellesley College Summer Program > Participating Faculty. [Online: http://www.wellesley.edu/Sumres/faculty/faculty.htm].
9. Summers, C.G. 1997. Phototactic behavior of *Bemisia argentifolii* (Homoptera: Aleyrodidae) crawlers. *Annals of the Entomological Society of America* 90(3):372–379.
10. Frank, K.D. 1988. Impact of outdoor lighting on moths: an assessment. *Journal of the Lepidopterists' Society* 42(2):63–93. Kolligs, D. 2000. Ecological effects of artificial light sources on nocturnally active insects, in particular on butterflies (Lepidoptera). *Faunistisch-Oekologische Mitteilungen* Supplement(28):1–136.
11. Kolligs, D. 2000. Ecological effects of artificial light sources on nocturnally active insects, in particular on butterflies (Lepidoptera). *Faunistisch-Oekologische Mitteilungen* Supplement 28:1–136. Eisenbeis, G., and F. Hassel 2000. [Attraction of nocturnal insects to street lights - a study of municipal lighting systems in a rural area of Rheinhessen (Germany).] *Natur und Landschaft* 75(4):145–156. Sustek, Z. 1999. Light attraction of carabid beetles and their survival in the city centre. *Biologia* (Bratislava) 54(5):539–551.
12. Frank, K.D. 1988. Impact of outdoor lighting on moths: An assessment. *Journal of the Lepidopterists' Society* 42:63–93. Rydell, J., and H. J. Baagoe. 1996. Street lamps increase bat predation on moths. Entomologisk Tidskrift 117:129–135. Kolligs, D. 2000. Ecological effects of artificial light sources on nocturnally active insects, in particular on butterflies (Lepidoptera). *Faunistisch-Oekologische Mitteilungen* Supplement:1–136. Eisenbeis, G., and F. Hassel 2000. [Attraction of nocturnal insects to street lights - a study of municipal lighting systems in a rural area of Rheinhessen (Germany).] *Natur und Landschaft* 75(4):145–156.
13. Tessmer, J.W., C.L. Meek, and V.L. Wright. 1995. Circadian patterns of oviposition by necrophilous flies (Diptera: Calliphoridae) in southern Louisiana. *Southwestern Entomologist* 20:439–445.
14. Gotthard, K. 2000. Increased risk of predation as a cost of high growth rate: an experimental test in a butterfly. *Journal of Animal Ecology* 69(5):896–902.

insects.[15] Mercury vapor streetlights especially increase bat predation on moths because the lights interfere with the ability of moths to detect the ultrasonic sound bursts used by bats to locate prey.[16]

Amphibians

Artificial night lighting has also been shown to affect the behavior of nocturnal frogs and toads, reducing their visual acuity and ability to consume prey.[17] Amphibians are particular about the light levels in which they will forage, and the crepuscular hours of dusk and dawn are often divided among species specializing in different light levels.[18] If the night does not become sufficiently dark, some species will never forage and will disappear from an area. In salamanders, similar partitioning of foraging times by lighting levels is being researched, and salamander diversity decreases under artificial lighting.[19] Only the species adapted to the lighted conditions can persist. Increased night lighting adjacent to wetlands can thereby reduce the number of species of amphibians that are present.

Fish

Fish respond to artificial light at night in varying ways. Some species are attracted to light sources, so much so that lights are used to lure fish up ladders to bypass dams.[20] Other fish will not forage in artificially lit areas or on nights with a full moon.[21] Seatrout in the United Kingdom provide an example. A tennis club built a lighted court adjacent to a productive seatrout pool on the Little Cowie River south of Aberdeen, Scotland. Seatrout are normally caught at night, especially on dark nights, when they forage at lighting levels between 0.5 and 0.2 lux. Foraging at greater illumination exposes the fish to greater predation. With the tennis court illuminated next to the river, the fish were no longer active in that pool. The local angling association ultimately took the tennis club to court and was successful in having the lighting declared a "light nuisance."[22] The effects of artificial lighting on juvenile and adult fish in the

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15. Blake, D., A.M. Hutson, P.A. Racey, J. Rydell, and J.R. Speakman. 1994. Use of lamplit roads by foraging bats in southern England. *Journal of Zoology* (London) 234:453–462.
16. Svensson, A.M., and J. Rydell. 1998. Mercury vapour lamps interfere with the bat defence of tympanate moths (*Operophtera* spp.; Geometridae). *Animal Behaviour* 55:223–226.
17. Buchanan, B.W. 1993. Effects of enhanced lighting on the behaviour of nocturnal frogs. *Animal Behaviour* 45(5):893–899.
18. Jaeger, R.G., and J.P. Hailman. 1976. Phototaxis in anurans: relation between intensity and spectral responses. *Copeia* 1976:352–407. Hailman, J.P., and J.G. Jaeger. 1976. A model of phototaxis and its evaluation with anuran amphibians. *Behaviour* 56:289–296. Hailman, J.P. 1984. Bimodal nocturnal activity of the western toad (*Bufo boreas*) in relation to ambient illumination. *Copeia* 1984:283–290.
19. Wise, Sharon. 2001. Personal communication.
20. Larinier, M., and S. Boyer-Bernard 1991. Smolt's downstream migration at Poutes Dam on the Allier River: use of mercury lights to increase the efficiency of a fish bypass structure. *Bulletin Francais de la Peche et de la Pisciculture* 323:129–148. Haymes, G.T., P.H. Patrick, and L.J. Onisto. Attraction of fish to mercury vapor light and its application in a generating station forebay. *Internationale Revue der Gesamten Hydrobiologie* 69:867–876.
21. Contor, C.R., and J.S. Griffith 1995. Nocturnal emergence of juvenile rainbow trout from winter concealment relative to light intensity. *Hydrobiologia* 299(3):179–183.
22. Stonehaven & District Angling Association. nd. Seatrout v light nuisance. [Online: http://www.sana.org.uk/light.htm].

Ballona wetlands has not been studied, but lighting may have important effects on behavior and ultimately affect the quality of the wetlands as fish habitat.

Birds

Artificial lighting affects behavior of birds in many ways. One of the most well-known examples is the attraction of migrating birds to tall, lighted structures (i.e., towers, office buildings, bridges), where they often die. While effects on migrating birds are possible from street lighting in some circumstances, other impacts are more likely. Lighting can affect bird species composition. For example, American crows (*Corvus brachyrhynchos*) roost in areas with high nighttime lighting levels,[23] where artificial lighting allows them to reduce predation from owls.[24] Crows are aggressive, and artificially increased population levels can be detrimental to other native bird species. Lighting can affect singing and foraging times for many species.[25] A review of the impact of artificial light on waterfowl records numerous instances of shorebirds foraging or roosting under artificial lights.[26] There is not yet information about whether these changes in behavior increase or decrease mortality.

Mammals

Finally, artificial lighting has significant effects on mammals. Large predators such as wolves and mountain lions, while clearly not an issue at the Ballona wetlands, are reported to avoid illuminated areas.[27] This may be important when addressing impacts of development that might eliminate landscape connections between coastal wetlands and other large natural areas. More likely of issue at Ballona wetlands is the effect of lighting on bat species. Some faster-flying bat species congregate at streetlights, while slower-flying species avoid them.[28] For fast species the agglomerations of insects at street lights are a source of food, but for slower species the increased food availability is offset by increased risk of predation by owls.

From the scientific literature on the effects of artificial lighting, we conclude that significant adverse impacts occur when the diurnal patterns of light and dark are disrupted. Because the

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23. Gorenzel, W.P., and T.P. Salmon. 1995. Characteristics of American Crow urban roosts in California. *Journal of Wildlife Management* 59(4):638–645.
24. Brody, J.E. 1997. The too-common crow is getting too close for comfort. *New York Times*, May 27. Miller, R. 1998. Flocks of crows making urban areas home, so look out below. *The News-Times*, December 28. [Online at: http://www.newstimes.com/archive98/dec2898/lcd.htm].
25. Bergen, F., and M. Abs. 1997. Etho-ecological study of the singing activity of the blue tit (*Parus caeruleus*), great tit (*Parus major*) and chaffinch (*Fringilla coelebs*). *Journal fuer Ornithologie* 138(4):451–467. Derrickson, K.C. 1988. Variation in repertoire presentation in northern mockingbirds. *Condor* 90(3):592–606. Hoetker, H. 1999. What determines the time-activity budgets of avocets (*Recurvirostra avosetta*)? *Journal fuer Ornithologie* 140(1):57–71. Frey, J.K. 1993. Nocturnal foraging by scissor-tailed flycatchers under artificial light. *Western Birds* 24(3):200. Hill, D. 1992. *The impact of noise and artificial light on waterfowl behavior: a review and synthesis of available literature*. British Trust for Ornithology Research Report No. 61.
26. Hill, D. 1990. *The impact of noise and artificial light on waterfowl behaviour: a review and synthesis of the available literature*. British Trust for Ornithology Research Report No. 61.
27. Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. *Journal of Wildlife Management* 59:228–237.
28. Rydell, J., and H.J. Baagoe. 1996. Bats & streetlamps. *Bats* 14(4):10–13.

proposed road improvement projects at the Ballona wetlands would trigger the installation of much higher lighting levels, such impacts will occur as a result of the project. Given this consequence, we believe that it would be prudent to fully explore the options for not lighting these intersections prior to approving these development permits. To make the finding that the increased lighting will not cause an adverse effect on the Ballona wetlands or other environmentally sensitive habitat areas, it is necessary to fully describe the lighting of the proposed project, and to provide measures to mitigate the impacts caused by it.

No state or federal law requires lighting of either intersection. However, if a roadway lighting system is included, failure to meet a voluntary national standard may result in increased liability for the jurisdiction. The standard is not compulsory, and does not weigh the effects of light on ecosystems in its formulation.[29] Therefore the Commission is free to impose lighting level standards without danger of conflicting with state or federal law. We suggest that the project be conditioned so that illuminance levels experienced by environmentally sensitive habitat areas surrounding the proposed projects are not increased throughout the life of the project. This performance objective could be achieved through a combination of lighting design, low (<3 feet) shields of native vegetation, and a mandatory inspection and maintenance regime for any lighting system.

Noise Impacts on Birds and Wildlife

Roads can exert a profound effect on birds and other wildlife through the production of noise. Two projects before the Commission would reconfigure an existing intersection, widen a stretch of road, and add a connector road. This will result in an increase in the noise levels experienced by wildlife within the Ballona wetlands. New road construction and road widening expands the area subjected to elevated sound levels. Widening Culver Boulevard will allow traffic to travel faster, which produces louder road noise.

Dutch scientists have conducted extensive research on the effect of road noise on birds. Their research shows that the breeding density of many species is depressed near roads. The research showed that up to a certain noise level, which differs for each species, no decrease occurs. Once the level is attained, called the “threshold,” breeding bird density decreases dramatically.[30] The decreased density over the area with noise greater than the threshold level ranges from 30% to 100% and is known as the “decrease factor.”[31] These two variables, the threshold value and the decrease factor, describe the impact of noise on breeding birds. For bird species similar to those found in the Ballona wetlands, the threshold level for decreased density is 43–60 dB(A).[32]

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29. Standard Practice Committee of the IESNA Roadway Lighting Committee. 2000. American national standard practice for roadway lighting (ANSI/IESNA RP-8-00). Illuminating Engineering Society of North America, New York, NY.
30. Reijnen, R., R. Foppen, C. ter Braak, and J. Thissen. 1995. The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads. *Journal of Applied Ecology* 32:187–202.
31. *Id*. at 192.
32. Reijnen, R., R. Foppen, and H. Meeuwsen. 1995. The effects of traffic on the density of breeding birds in Dutch agricultural grasslands. *Biological Conservation* 75(1996): 255–260.

Two explanations are suggested for the decreased abundance of breeding birds at elevated noise levels. First is the disruption of vocal communication. Male birds are perhaps unable to attract females when their songs cannot be heard. A complementary hypothesis is that birds avoid noisy areas because they are stressful.[33] Increased stress because of difficult communication leads to an increase in emigration (birds leaving the area) and decrease in reproduction [34]

Detrimental effects of road noise are recorded for many species of wetland-associated birds. Of particular concern at the Ballona wetlands is Belding's savannah sparrow, a state-listed endangered species. Noise from the project could have a significant impact on this and other bird species. In studies of wetland birds (lapwing, black-tailed godwit, redshank), a zone of decreased density of 500–600 m was found for a rural road, and 1600–1800 m for a busy highway.[35] The zone increases with the width of the road and the volume and speed of traffic.

The body of research on the effects of noise on vertebrates shows that chronic noise, even at low levels, is associated with elevated stress hormone levels, higher blood pressure, faster heart rates, and other physiological effects.[36] As a result, birds, mammals, and other vertebrates may show anatomical differences (smaller body size, enlarged adrenal glands) from prolonged exposure to noise.

The potential of road noise to render less useful otherwise productive wetland habitats exists for any reconfiguration or construction project. If roads are widened, or redesigned to accommodate traffic flow at higher speeds, an increased area will be exposed to chronic elevated noise levels. These effects should be carefully considered when such projects are proposed close to wetland and other natural habitats.

Roadkill

Another direct pathway of road effects is through direct mortality of wildlife. The taxonomic breadth of deaths from collisions with vehicles is wide and well documented.[37] In wetland situations, amphibians and small mammals are particularly vulnerable. The percentage of individuals in a vertebrate population killed on roads increases with the width of the road, and with the number of vehicle trips on the road.[38] So even in instances where roads already exist,

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33. Illner, H. 1992. Effect of roads with heavy traffic on grey partridge (*Perdix perdix*) density. *Gibier Fuane Sauvage* 9:467–480.
34. Reijnen, R., R. Foppen, and G. Veenbaas. 1997. Disturbance by traffic of breeding birds: evaluation of the effect and considerations in planning and managing road corridors. *Biodiversity and Conservation* 6:567–581.
35. van der Zande, A.N., W.J. Keurs, and W.J. van der Weijden. 1980. The impact of roads on the densities of four bird species in an open field habitat — evidence for a long distance effect. *Biological Conservation* 18:299–231.
36. Manci, K.M., D.N. Gladwin, R. Villella, and M.G. Cavendish. 1988. *Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis*. U.S. Fish and Wildlife Service National Ecology Research Center, Ft. Collins, CO. NERC-88/29. 88 pp.
37. See reviews in Groot Bruderink, G.W.T.A., N.N. Beyer, and L.P. Franson. 1986. Ungulate traffic collisions in Europe. *Conservation Biology* 10:1059–1076, and Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14:18–30.
38. Carr, L.W., and L. Fahrig. 2001. Effect of road traffic on two amphibian species of differing vagility. *Conservation Biology* 15:1071–1078. Hels, T., and E. Buchwald. 2001. The effect of road kills on amphibian

widening from two lanes to four can sever population connections between habitats bisected by the road. In Area C at Playa Vista, which is bisected by Culver Boulevard, Audubon's cottontails are still present. Increasing Culver Boulevard from two to four lanes, combined with cumulative impacts of separate projects widening Lincoln Boulevard, may result in an isolation of these populations. This would increase the risk that they will be extirpated from one or more areas and decreases the probability of recolonization.

Birds are also vulnerable to roadkill. Birds of prey are often killed along roads where they have come to forage in roadside vegetation. One of the authors of this report observed a roadkilled Barn Owl along Culver Boulevard in the project site in December 1996. The specimen was collected and deposited in the Natural History Museum of Los Angeles County. Increasing the width of Culver Boulevard will increase direct mortality, and further fragment the open space of Area C.

Water Quality and Detention Basins

Increased road area generates an increase in five types of chemicals in the surrounding environment. Trombulak and Frissell identify and discuss the effects of these pollutants, heavy metals, salt, organic molecules, ozone, and nutrients.[39] While many of these may have impacts to water quality, they have other detrimental impacts in the environment. Often effects of road pollution are only analyzed for water quality effects in a receptor water body downstream, not for the effects to the terrestrial communities adjacent to the road. Heavy metals accumulate in the tissues of plants and animals up to 200 m away from roads.[40] Deicing salts are particularly harmful to plants, but are not an issue in southern California. Complex organic molecules, such as polycyclic hydrocarbons, accumulate along roads and are toxic to many organisms. For example, these compounds accounted for toxicity of water along a road in Britain to aquatic invertebrates.[41] Roads increase atmospheric ozone, which contributes to respiratory problems in mammals just as it does in humans. Finally, roads are sources of excess nutrients for nearby environments. One such nutrient is nitrogen, which is released during combustion of fossil fuels. Even very low levels of excess nitrogen can be affect aquatic vertebrates such as amphibians.

Nitrates and nitrites have been implicated in global amphibian declines. The pathways of effect are many. Increased nitrates influence prey distribution and behavior.[42] Rouse *et al*. review laboratory studies that report lethal and sublethal effects of nitrates on amphibians at

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populations. *Biological Conservation* 99:331–340. Lode, T. 2000. Effect of a motorway on mortality and isolation of wildlife populations. *Ambio* 29:163–166.

39. Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14:18–30.
40. Id.
41. Maltby, L. A.B.A. Boxall, D.M. Farrow, P. Calow, and C.I. Betton. 1995. The effects of motorway runoff on freshwater ecosystems. 2. Identifying major toxicants. *Environmental Toxicology and Chemistry* 14:1093–1101.
42. Watt, P.J., and R.S. Oldham. 1995. The effect of ammonium nitrate on the feeding and development of larvae of the smooth newt, *Triturus vulgaris* (L.), and on the behaviour of its food source, *Daphnia*. *Freshwater Biology* 33:319–324. Rouse, J.D., C.A. Bishop, and J. Struger. 1999. Nitrogen pollution: an assessment of its threat to amphibian survival. *Environmental Health Perspectives* 107:799–803.

concentrations equaling 2.5–100 mg/L.[43] Laboratory studies have shown significant larval mortality at 1 mg/L, which meets safe drinking water standards, with all four species studied showing significant effects at 2 mg/L.[44] Studies often show larval deformities and altered metamorphosis phenology in response to nitrogen pollution.[45] In another effect pathway, stress, such as that induced by exposure to sublethal nitrogen pollution, is hypothesized to weaken amphibian immune systems, which makes individuals vulnerable to infection by pathogens[46] such as bacteria or chytrid fungi.[47] Increased nitrogen loading in wetlands and constructed detention basins may be a significant detrimental byproduct of the proposed road construction and expansion.

Mitigation for the increased pollution created by the road widening of Culver Boulevard is proposed in the form of a wetland detention basin or bioswale. It is argued that the quality of stormwater reaching Ballona Creek will be better after project implementation. However, even if the water flowing into Ballona Creek is cleaner, there will still be more pollution in the Ballona wetlands ecosystem as a result of the project. The bioswale is designed to "clean" the water that flows into it. However, while the pollutants may be kept out of the runoff flowing out of the swale, many are retained within the bioswale, where they can affect plants and wildlife. Even though bioswales may provide habitat for birds and other wildlife, they are by design polluted habitats. So while they may mitigate water quality issues, they do not minimize or even reduce the amount of pollution experienced by plants and wildlife.

The ability of bioswales to remove pollutants from stormwater is also not perfect. In a very recent study of bioswales constructed by Caltrans in San Diego similar to that proposed at Culver Boulevard, performance was monitored for three years.[48] Suspended solids experienced an average load removal of 73%. Nitrogen forms were reduced by only 17% and phosphorus was reduced by 38%. Between 61–75% of the total concentration heavy metals was reduced, while only 16–44% of dissolved metals was reduced. Concentrations of complex hydrocarbons from

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43. Rouse, J.D., C.A. Bishop, and J. Struger. 1999. Nitrogen pollution: an assessment of its threat to amphibian survival. *Environmental Health Perspectives* 107:799–803.
44. Marco, A., C. Quilchano, and A.R. Blaustein. 1999. Sensitivity to nitrate and nitrite in pond-breeding amphibians from the Pacific northwest, USA. *Environmental Toxicology and Chemistry* 18:2836–2839.
45. Xu, Q., and R.S. Oldham. 1997. Lethal and sublethal effects of nitrogen fertilizer ammonium nitrate on common toad (*Bufo bufo*) tadpoles. *Archives of Environmental Contamination and Toxicology* 32:298–303. Jofre, M.B., and W.H. Karasov. 1999. Direct effect of ammonia on three species of North American anuran amphibians. *Environmental Toxicology and Chemistry* 18:1806–1812. Hecnar, S.J. 1995. Acute and chronic toxicity of ammonium nitrate fertilizer to amphibians from southern Ontario. *Environmental Toxicology and Chemistry* 14:2131–2137.
46. Carey, C. 1993. Hypothesis concerning the causes of the disappearance of boreal toads from the mountains of Colorado. *Conservation Biology* 7:355–362.
47. Berger, L., R. Speare, P. Daszak, D.E. Green, A.A. Cunningham, C.L. Goggin, R. Slocombe, M.A. Ragan, A.D. Hyatt, K.R. McDonald, H.B. Hines, K.R. Lips, G. Marantelli, and H. Parkes. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *Proceedings of the National Academy of Sciences of the United States of America* 95:9031–9036. Lips, K.R. 1999. Mass mortality and population declines of anurans at an upland site in western Panama. *Conservation Biology* 13:117–125.
48. Taylor, S.M., Hanson, L., and C. Beitia. 2001. Assessment of costs and benefits of detention for water quality enhancement. Paper read at American Society of Civil Engineers World Water & Environmental Resources Congress 2001, Orlando, FL, May 20–24, 2001.

diesel and oil were only reduced by 3% and 25% respectively, while fecal coliform levels were 200% *higher* in water flowing out of the detention basin than flowing in. The basins studied represent the state of the art and were well maintained during the study. Results such as this in the scientific literature raise legitimate concerns about the reliance on detention basins for stormwater treatment. It further brings into question the assertion by the applicant that water flowing into Ballona Creek will be cleaner after the project than before. If previous experience is to be a guide, it would be reasonable to expect that following expansion of Culver Boulevard significantly more pollutants (diesel, oil, dissolved heavy metals, fecal coliform bacteria) will flow into Ballona Creek than before. The evidence from the 2001 study contradicts the statement by the applicant's consultant (repeated in the staff report) that levels of coliform bacteria can be reduced by over 50% in water quality basins.

Other Issues

The special conditions for the project widening Culver Boulevard include a requirement for the use of Integrated Pest Management ("IPM") in landscape and bioswale areas. Suggested methods include the release of toads, garter snakes, and predatory insects. It is not advisable to introduce more exotic species into a system already so burdened by exotics. The use of predators as biocontrol agents is controversial in the scientific community, and impacts on non-target species must be carefully considered. Only introduction of species native to the Ballona wetlands should be allowed as part of the Integrated Pest Management program.

The recommendations for the IPM also include "trapping manually." While it is unclear what species would be trapped, the target would presumably be pocket gophers. Burrowing mammals are often removed in the maintenance of bioswales.[49] However, gophers have profound ecosystem benefits, including increased humus content, mineral availability, soil moisture, and friability,[50] all of which are beneficial to native plant communities. They are also prey for raptors. While burrowing mammals can present a challenge to the establishment of vegetation, their presence increases the long term viability of the ecosystem.

Conclusion

Wetlands are critically important to ecosystem function and the maintenance of biodiversity. Our understanding of the impacts of development of roads near and through wetlands provides more than ample evidence to argue for caution when weighing the need for a project against the impact the resource. Unfortunately, the environmental review process does not always keep pace with scientific understanding. The proposed projects are mitigations for traffic impacts

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49. Id.
50. Dalquest, W.W. and V.B. Schaffer. 1942. Origin of mima mounds in western Washington. *Journal of Geology* 50:68–84. Ellison, L. and C.M. Aldous. 1952. Influence of pocket gophers on vegetation of subalpine grassland in central Utah. *Ecology* 33:177–186. Hansen, R.M. and M.J. Morris. 1968. Movement of rocks by Northern Pocket Gophers. *Journal of Mammalogy* 49:391–399. McGinnes, W.J. 1960. Effect of mima-type microrelief on herbage production of five seeded grasses in western Colorado. *Journal of Range Management* 13:231–239. Mielke, H.W. 1977. Mound building by pocket gophers (*Geomyidae*): their impact on soils and vegetation in North America. *Journal of Biogeography* 4:171–180. Ross, B.A., J.R. Tester, and W.J. Breckenridge. 1968. Ecology of mima-type mounds in northwestern Minnesota. *Ecology* 49(1):172–177.

evaluated in an Environmental Impact Report prepared nearly a decade ago. As is usually the case, the environmental impacts of the mitigation measures themselves were not sufficiently evaluated. Furthermore, increased scientific knowledge during the intervening years leads to the conclusion that resource agencies should be more, not less, restrictive when approving roads in and near wetlands.

This review has shown several pathways through which reconfigured and expanded roads through the Ballona wetlands ecosystem can impact environmentally sensitive habitat areas and the wildlife dependent on them. These pathways include increased light, noise, roadkill and pollution. We conclude that these impacts will still occur if the projects are approved as proposed and conditioned by staff and would conflict with the resource protection statutes of the California Coastal Act.