

county of ventura

November 10, 2015

Board of Supervisors
County of Ventura
800 South Victoria Avenue
Ventura, CA 93009

SUBJECT: Receive, File and Provide Direction on the Pending Projects List for the Resource Management Agency, Planning Division, Long-Range Planning Section's Work Program

RECOMMENDATIONS:

1. **RECEIVE & FILE** staff's presentation regarding recommendations for the phased completion of pending projects by the RMA/Planning Division.
2. **PROVIDE DIRECTION** to staff regarding the first phase of work on the Pending Projects List, subject to future Board authorizations and budget transactions.

FISCAL MANDATES/IMPACTS:

There is no immediate fiscal impact associated with the recommended actions, but decisions regarding the timing and funding for pending projects could affect the RMA/Planning Division budget in the current or future fiscal years. No new County staff positions would be required to complete the Pending Projects List¹, and the actual amount of future Board-allocated funding would be confirmed by updated cost estimates. In addition, the actual amount of necessary Board-allocated funding will be dependent on future decisions regarding two projects² that require cost-benefit or project-feasibility analyses prior to project initiation. Ultimately, Board-allocated funding would be authorized either on a project-specific basis or as part of the annual budgeting process for the RMA/Planning Division.

DISCUSSION:

Background

The Long-Range Planning Section of the RMA/Planning Division is charged with processing updates and amendments to the County's General Plan, Area Plans, Non-Coastal Zoning Ordinance, Coastal Zoning Ordinance, and Subdivision Ordinance. As

¹ The Pending Projects list does not include the General Plan Update.

² Mitigation Bank Program, Decks in the Coastal Zone



part of the 2015 Annual Report, which was presented to your Board on May 19, 2015, staff provided your Board with a complete list of “projects” or work programs related to its primary mission. Those work programs were generally divided into the following groups:

- Recently Completed Projects
- Active Projects List, including ongoing work programs
- Pending Projects List
- Inactive Projects List.

Exhibit 1 contains a summary of active projects, ongoing work programs, and inactive projects. Since your Board received the 2015 Annual Report, the Active Projects List was reduced by the adoption of the Saticoy Area Plan update on September 22, 2015. Outstanding active projects include two, large grant-funded projects, the Coastal Biology and the Local Coastal Program (LCP) Amendments. A large group of LCP Amendments is scheduled for your Board’s review next year and, due to a federally-mandated deadline, these projects remain high-priority work programs. The Active Projects List was recently expanded when your Board approved a scope-of-work and a preliminary, proposed budget and timeline for the Ventura County General Plan Update (GPU). A separate team is currently being developed to work with consultants on a comprehensive update to the General Plan, which is slated for completion by mid-2020.

The Long-Range Planning Section is also responsible for a wide variety of ongoing programs – such as the State-mandated Annual Report, the annual update to the Locally Important Species List, and Board pre-screenings for privately-initiated amendments. For example, a privately-initiated Board pre-screening application was recently submitted for the redevelopment of the 98-acre, former USA Petrochem Refinery Site, which is located within the boundary of the North Ventura Avenue Area Plan. Should your Board approve this pre-screening for further processing, it is likely that the project would need to be processed concurrently with a broader update of the North Ventura Avenue Area Plan.

Pending Projects List

The Pending Projects List includes work programs that are either required by State law or were previously identified by your Board. Generally, pending projects are those projects awaiting available staff resources and budget allocations. With the recent completion of the Saticoy Area Plan update, and the anticipated completion of the Coastal Biology and LCP Amendments projects next year, existing staff will be available to initiate work on a number of these pending projects. Also, during your Board’s review process for the GPU scope-of-work, several Board members emphasized the importance of continued work on pending projects, and indicated that it would be helpful to review and prioritize the list of projects prior to adoption of a final budget and scope-of-work for the GPU.

In order to assist your Board's discussion of the Pending Projects List, a detailed description of each project is provided in Exhibit 2. Also included is a preliminary assessment of cost estimates, project duration, and potential funding sources. There are sixteen individual work programs that comprise the current Pending Projects List, and they are divided below into three groups: State-mandated programs, 2014-2021 Housing Element programs, and Board-initiated programs. Board-initiated programs are listed in the chronological order in which they were identified, and they include two projects that are currently expected to be programmed and funded through the GPU (while the Concurrent Zoning Ordinance Update is essentially linked to the GPU, the Habitat Connectivity project could proceed independent of the GPU).

State-Mandated Programs:

- Inconsistent Zoning (existing)
- Supportive and Employee Housing
- Landscape Guidelines (update for water-efficient regulations)
- 2022-29 Housing Element

2014-21 Housing Element Programs:

- Farmworker Housing Standards
- Senior Citizen Housing Needs
- Second Dwelling Unit Program
- Housing Impact Fee Mitigation Ordinance
- Inclusionary Housing Ordinance

Board-Initiated Programs:

- Habitat Connectivity Protection Overlay Zone (GPU)
- Mitigation Bank Program
- Senior Citizen Mobile Home Park Overlay Program
- Ojai Valley Dark Skies Ordinance
- Decks in the Coastal Zone
- Saticoy Implementation Programs (years 0 - 5)
- Concurrent Zoning Ordinance Update (GPU)

Recommended Order of Project Processing

In order to facilitate your Board's review of pending projects, this section provides a recommended order for project processing. A brief explanation is provided for the recommendations, which generally reflect the following priorities:

- *Legal mandates/issues:* Projects required by legal mandates are prioritized, and programs identified by the existing Housing Element are timed for completion prior to the initiation of the next Housing Element.

- *Resolution of pressing problems:* Projects that will help resolve outstanding planning problems or permitting issues are prioritized.
- *Small projects:* These generally fell into the “just do it” category, and are timed to occur between larger projects.
- *Concurrent processing:* Similar types of projects are grouped together to comprehensively address related planning issues and reduce processing costs.
- *Staff Skills / Availability:* Projects that require specific skills or a specialized knowledge base may be delayed until a particular staff member is available.
- *Outstanding legal issues:* Projects were delayed when subject to ongoing legal challenges.

In two cases (Mitigation Bank Program, Decks in Coastal Zone), cost-benefit or project feasibility reviews would be conducted prior to the initiation of specific projects. That information would be reported back to the Board prior to beginning work on the entire project.

Pending Projects List: Recommended Order of Processing

No.	Name of Project	Explanation
1	Existing Inconsistent Zoning Exhibit 2: Project #1	This project should be prioritized because State law mandates that zoning be consistent with the General Plan, and the County currently has several hundred parcels with inconsistent zoning. In addition, zoning affects the use of land and how it is developed (i.e. allowable uses, building heights, setbacks, minimum lot sizes, etc.). Given the number, location, and type of parcels with inconsistent zoning, this project would be completed in phases, with higher-priority rezones processed first. At the outset, staff would conduct an assessment of the problem and develop a more detailed plan for resolving inconsistent zoning.
	Special Needs Housing	<i>The four, related housing programs listed below (items numbered 2, 3, 4, and 5) would be processed concurrently:</i>
2	Supportive and Employee Housing Exhibit 2: Project #2	This project is a recently adopted State mandate that does not require major revisions to County regulations. Costs to process the required NCZO amendments should be reduced by completing this project concurrently with other housing programs.
3	Farmworker Housing Standards Exhibit 2: Project #5	This project is required by the 2014-2021 Housing Element. It should be prioritized because farmworker housing is an important type of special-needs housing that affects the County's agricultural economy as well as farmworkers and their families.
4	Senior Citizen Housing Needs	This project is a 2014-2021 Housing Element program, and it would address the growing need for specialized types of housing for senior citizens, which may warrant specific development

No.	Name of Project	Explanation
	Exhibit 2: Project #6	standards (such as reduced parking) to help facilitate such projects or ensure they are appropriately located and designed. This issue is timely given the forecast increase in the senior citizen population in Ventura County.
5	Senior Mobile Home Park Overlay Zone Exhibit 2: Project #12	This project is related to the Senior Citizen Housing Needs program, shown above, and it makes sense to process them concurrently so that senior citizen housing needs are addressed in a comprehensive manner.
6	Habitat Connectivity Protection Overlay Zone (GPU) Exhibit 2: Project #10	This project should be prioritized because a significant amount of work has already been completed. In addition, staff has been seeking grant opportunities to supplement funding for this project. Since grant opportunities have been unavailable, allocation of funding from the Board will be needed. However, the timing for project re-initiation is dependent upon completion of two active projects (Coastal Biology, LCP Amendments), which are assigned to specialized staff (staff biologist). Biology-related work on those projects is currently on hold due to a staff vacancy.
7	Ojai Dark Skies Ordinance Exhibit 2: Project #13	This is a mid-sized project that could be initiated in FY2016-17, following completion of the LCP amendments. At that time, staff will become available for new projects.
8	Saticoy Area Plan Implementation Programs Exhibit 2: Project #15	This project covers seven different tasks, which are scheduled for completion during years 0 to 5 following Area Plan adoption. Although this project would be started in 2016, it would be conducted in phases during a five-year period.
9	Landscape Guidelines Update Exhibit 2: Project #3	This is a relatively small project that requires an update to the existing Guidelines to address new, State-mandated water-efficient landscaping requirements. This update will be based on regulations currently being developed for the coastal zone, and the project will be initiated after adoption of the LCP amendments.
10	Mitigation Bank Program Exhibit 2: Project #11	This is a potentially large project that would consume substantial staff resources, but the initial scope-of-work is limited to the preparation of a problem/solutions options assessment and a report back to the Board (see Exhibit 2 for details).
11	Second Dwelling Units Exhibit 2: Project #7	This is a small, "just do it" project that would be initiated following adoption of the LCP amendments. Work is focused on a grant application, and timing of the larger project would depend on the receipt of a grant award. This project may also be combined with a similar on-going project in Building & Safety related to farmworker housing units.
12	Housing Impact Fee Ordinance Exhibit 2: Project #8	This project is a 2014-2021 Housing Element program, and it would be processed concurrently with a related project, the Inclusionary Housing Ordinance (concurrent processing also

No.	Name of Project	Explanation
		reduces consultant fees). This project is not considered a high priority because of its limited applicability (no affected project applicants since 2010). Also, our housing specialists won't become available until the special needs housing projects (items 2 through 5) are completed.
13	Inclusionary Housing Ordinance Exhibit 2: Project #9	This project is a 2014-2021 Housing Element program, and it would be processed concurrently with a related project, the Housing Impact Fee Ordinance (concurrent processing also reduces consultant fees). This project was placed on hold due to ongoing legal challenges to inclusionary housing, and the case is currently on appeal at the U.S. Supreme Court level. Prior to project initiation, a cost-benefit assessment is recommended (see Exhibit 2 for details).
14	Decks in Coastal Zone Exhibit 2: Project #14	This project would allow decks in setbacks within the coastal zone. This project is expected to be complicated by potential problems related to building codes, storm-water management regulations, and the California Coastal Commission's newly adopted Sea Level Rise Guidance Document. As such, a project feasibility assessment would be conducted prior to project initiation.
15	Concurrent Zoning Ordinance Updates (GPU) Exhibit 2: Project #16	Concurrent zoning ordinance updates is a recommended work program within the General Plan Update (GPU) project. The timing for necessary map and text amendments would be determined by the GPU project manager, but typically a zoning ordinance consistency process would be initiated during the latter part of an update process. This project also includes necessary zoning ordinance updates previously identified by Planning Division staff.
16	2022-29 Housing Element Exhibit 2: Project #4	Timing for the 2022-29 Housing Element is dependent on State-mandated schedules, and it is probable that the Regional Housing Need Assessment, or RHNA, won't be available until late 2020. Also, the 2022-29 Housing Element is not scheduled for submittal to the State until late 2021. Given those timelines, this project will probably be the last to be initiated in the Pending Projects list.

Pending Projects Schedule

It is estimated that the first fifteen items on the recommended priority list above can be completed by Planning Division staff within the next five years. It is also anticipated that the remaining project (2022-29 Housing Element) will require an additional year due to State-mandated timelines. As noted, several of the projects will be completed concurrently, and some projects will be completed as part of the General Plan Update.

The following table provides a generalized summary of the project delivery schedule based on the recommended priority list. This should be viewed as a rough guide to the implementation schedule. The schedule is based on the Planning Division's initial assessment of the time and resources needed to complete pending projects, and it is intended only to provide a high level overview for delivery dates. Actual schedules may be affected by updated information, new Board initiatives, or new State mandates.

Pending Projects: Preliminary Schedule for Project Completion

Project Name	CALENDAR YEAR						Total FTE
	2016	2017	2018	2019	2020	2021	
1 Inconsistent Zoning (Existing) SM							2.00
2 Supportive & Employee Housing ^{1, SM}							0.25
3 Farmworker Housing Standards ^{1, HE}							1.75
4 Senior Citizen Housing Needs ^{1, HE}							1.50
5 Senior Mobile-home Park Overlay Zone ^{1, BI}							0.25
6 Habitat Connectivity Prot. Overlay Zone ^{3, GPU}							1.00
7 Ojai Dark Sky Ordinance ^{BI}							1.00
8 Saticoy Implementation Programs (0 - 5) ^{BI}							1.75
9 Landscape Guidelines (Update) SM							0.25
10 Mitigation Bank Program ^{2, BI}							0.25
11 Second Dwelling Unit Program ^{HE}							0.50
12 Housing Impact Fee Ordinance ^{HE}							1.50
13 Inclusionary Housing Ordinance ^{HE}							2.00
14 Decks in Coastal Zone ^{BI}							1.25
15 Concurrent Zoning Ordinance Update ^{GPU}							1.75
16 2022-29 Housing Element SM							3.50
							20.50

- ¹ Special Needs Housing to be processed concurrently
² Feasibility/Assessment Report Only
³ If initiated separately from the GPU, may be completed in 2018.
SM State-Mandated
^{HE} Housing Element
^{BI} Board-Initiated
^{GPU} General Plan Update

Project Funding Assessment

The primary funding source for the pending projects is the annual Planning Division Budget and the permit fees and general funds that support General Plan and Ordinance revision activities. This funding is augmented by grant funds as well as any new, project-specific Board-allocated funds. After setting aside the resources necessary to handle ongoing work programs, it was determined that more than eighty percent of the costs associated with completion of the Pending Projects List are anticipated to be provided through the annual Planning Division Budget revenues and the GPU. As noted above, this is dependent on the outcome of privately-initiated screening activities as well as the outcome of recommended cost-benefit/feasibility studies for two of the pending projects.

The Long-Range Planning Section regularly monitors grant opportunities, and staff apply for grants that align with the objectives of its work program. Historically, the RMA/Planning Division relied on grants to support a portion of its work programs. For example, a substantial share of the costs for the recently completed Saticoy Area Plan Update was paid through grant awards. However, previously obtained grant awards are nearly depleted, and there are few available grants that align with the objectives of Pending Projects List. In general, the number of grants available for planning work is limited. Moreover, staff was recently informed that the federal government plans to target the next round of Coastal Impact Assistance Program (CIAP) grants towards projects located along the eastern U.S. seaboard. While Planning Division staff will continue to monitor and apply for grant awards, reliance on grant funds is not recommended for high-priority projects or projects that do not closely align with available grant opportunities.

Next Steps

Planning Division staff recently began preliminary work on the Existing Inconsistent Zoning project and the Housing Element implementation programs. Once a Board decision is rendered regarding the preferred order for completing work on the Pending Projects List, staff will begin work in earnest on those and other projects. Should the Board elect to move forward with the recommended time frame and order for completing the list of pending projects, then no additional Board-allocated funds will be necessary during the current fiscal year.

The need for additional, Board-allocated funds will be reassessed on an annual basis, and the Planning Division will report back to the Board on an annual basis regarding updated cost estimates, cost-benefit or project feasibility analyses, and the expected need for Board-allocated funds during an upcoming fiscal year. Reports back to your Board will most likely occur as part of the Annual Report or during the annual RMA/Planning Division budget process. As previously noted, it is currently anticipated that completion of the Pending Projects List can be accomplished with existing staff positions assigned to the Long-Range Planning Section of the RMA/Planning Division.

This letter was reviewed by the offices of the County Executive Office, Auditor-Controller's Office, and County Counsel. If you have any questions regarding this matter, please contact

me at (805) 654-2481 or Rosemary Rowan, Planning Manager, Long Range Planning Section at (805) 654-2461.

Sincerely,

A handwritten signature in black ink, appearing to read "Kim Prillhart", written over a horizontal line.

Kim Prillhart, Director
Ventura County Planning Division

Attachments:

Exhibit 1: Active Projects, Inactive Projects, and Potential Projects

Exhibit 2: Pending Projects List

See following development and use allowed in the non-coastal zone Open Space and Ag Lands that may be important for HCOZ:

Exempted

Animal Husbandry
Crop and Orchard Production
Timber Growing and Harvesting
Animal Keeping (non-husbandry pets and horses)
Accessory Structures for horses and pets
Fences and walls less than 6 feet
Grading (A PW permit may be required)
Public works maintenance for mineral resource development
Trees and native veg removal for non-protected trees or overlay zones
Recyclable household and hazardous waste collection
Small utility structures for public works?

Zoning Clearance/Ministerial Permit

Animal Husbandry with reduced animal setbacks
Principal and accessory structures related to ag (up to 20k square feet each category)
Wineries (Up to 2k structure)
Wholesale nurseries and ag sales facilities (up to 500 square feet)
Farmworker housing dwelling units
Animal Caretaking Units
Fuel Storage Areas
Animal Keeping with reduced animal setbacks
Single family dwellings
Second dwelling units
Garage and storage buildings
Accessory structures for wild animals
Fences and walls over 6 ft high
Mining in agricultural site
Recycling Collection Center
Temporary Collection Activities
Signs
Parks no buildings?

(List assembled by Abigail Convery – April 2017)

ORDINANCE NO. _____

**AN ORDINANCE OF THE COUNTY OF VENTURA, STATE OF CALIFORNIA,
AMENDING DIVISION 8, CHAPTER 1, ARTICLES 2, 3, 4, 5, AND 9
OF THE VENTURA COUNTY ORDINANCE CODE, NON-COASTAL ZONING ORDINANCE
TO REGULATE DEVELOPMENT WITHIN THE REGIONAL HABITAT LINKAGES AND THE
CRITICAL WILDLIFE PASSAGE OVERLAY ZONES**

The Board of Supervisors of the County of Ventura ("County") ordains as follows:

Section 1.

**ARTICLE 2:
DEFINITIONS**

Article 2, Section 8102-0 – Application of Definitions, of the Ventura County Ordinance Code is hereby amended to add the following definitions in appropriate alphabetical order:

Agricultural Water Impoundment – A human-made surface water source used for livestock watering or other agricultural purposes (e.g., agricultural reservoir), also referred to as farm pond or livestock pond, in which water supply is primarily fed by sources other than natural processes such as groundwater seep or precipitation.

Compact Development – A design technique that involves grouping development in one area of a lot, while preserving the remaining portion for other uses such as protection of environmentally sensitive areas, such as wildlife movement corridors.

Conservation Organization – A natural resource agency or a private, non-profit organization, whose primary purpose is the preservation and protection of land in its natural, scenic, historical, recreational, or open space condition.

Correlated Color Temperature - A measure in degrees *Kelvin* (°K) of the warmth or coolness of light. Lamps with a *correlated color temperature* of less than 3,000°K are pink or yellow in tone and considered warm. Lamps with a *correlated color temperature* greater than 4,000°K are blue–white in tone and considered cool.

Critical Wildlife Passage Areas – Areas of land identified within a *regional habitat linkages* area that are especially valuable due to the existence of one or more of the following elements: 1) intact, native habitat or higher habitat values; 2) proximity to water bodies or ridgelines; 3) proximity of critical roadway crossings; 4) likelihood of encroachment by future development, and within which wildlife movement and plant dispersal could be easily disturbed by development; or 5) presence of undeveloped lands within a geographic location that connects core habitats at a regional scale. These include areas within the Tierra Rejada Valley, areas

within Oak View; and areas within the Simi Hills. These areas are mapped in an overlay on the County Resource Management Agency's Geographic Information System and referred to as "critical wildlife passage areas."

Functional Connectivity - Describes the degree to which a physical setting (landscape) facilitates or impedes the movement of organisms. *Functional connectivity* is a product of both the features of the physical setting (e.g., vegetation, physical development) and the behavioral response of plants and animals to these physical features.

Glare - The sensation produced by a bright source within the visual field that is sufficiently brighter than the level to which the eyes are adapted, causing annoyance, discomfort, or loss in visual performance and visibility.

Invasive Plant – Any species of plant included on the California Invasive Plant Council *Invasive Plant Checklist for California Landscaping*, as amended (<http://www.cal-ipc.org/plants/inventory/>).

Kelvin - A unit of measure used to describe the hue (or *correlated color temperature*) of a light source.

Least Damaging Alternative Analysis - The evaluation of project alternatives that aims to minimize adverse impacts on *regional habitat linkages* and the resources that facilitate *functional connectivity*, such as *vegetation*, *surface water features*, and *wildlife crossing structures*.

Light Fixture – See *luminaire*

Light Pollution - Adverse effects of artificial light including, but not limited to, *glare* and *light trespass*, and impacts on the nocturnal environment, including light sources that are left on when they no longer serve a useful function.

Light Trespass or Light Spillover - Light emitted from a *luminaire* or installation that shines beyond the boundaries of the property on which it is sited.

Lighting, Directional - Adjustments made to a *luminaire* to focus light where it is needed.

Lighting, Seasonal or Festive – *Temporary* lighting installed and operated in connection with holidays, traditions or festivities.

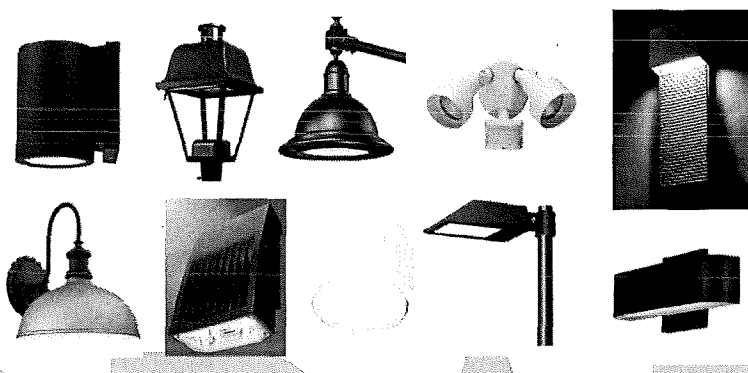
Lighting, Security – A *luminaire* that is primarily intended to deter or detect intrusions or other unwanted activity. It can also be used to allow safe passage.

Lumen - Unit of measure used to quantify the amount of light produced by a lamp or emitted from a *luminaire* (as distinct from a "watt," which is a measure of power consumption).

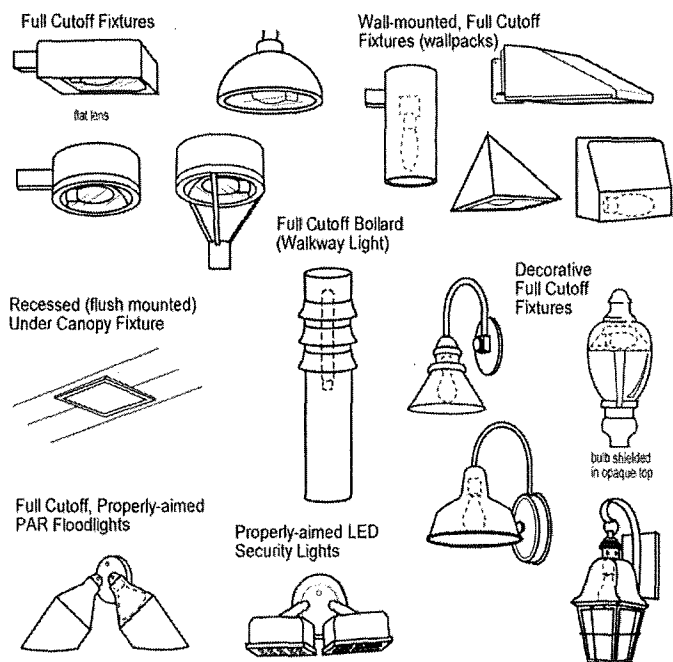
Luminaire - A complete lighting unit consisting of the lamp and all components directly associated with the distribution, positioning and protection of the lighting unit, commonly referred to as a light fixture.

Luminaire, Fully-Shielded - A *luminaire* constructed and installed in such a manner that all light emitted by the fixture is projected below the horizontal plane through the fixture's lowest light-emitting part.

Examples of Fully-Shielded Luminaires



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Luminaire, Partially-Shielded - A *luminaire* constructed and installed such that most light emitted by the fixture is projected below the horizontal plane through the fixture's lowest light-emitting part. Light emitted above the horizontal plane arises only from decorative elements or diffusing materials such as frosted/colored glass or plastic.

Examples of Partially-Shielded Luminaires



Outdoor Lighting - Any *luminaire* that is installed outside the interior of a structure. The *luminaire* could be mounted to the exterior of a structure, mounted to poles, fences or other freestanding structures, or placed to provide direct illumination on any exterior area, object or activity. Outdoor lighting includes but is not limited to *luminaires* used for porches, landscapes, *security lighting*, *fences*, driveways and walkways, parking areas, and *outdoor recreation areas*.

Outdoor Recreational Area – An area designed for active recreation, whether publicly- or privately-owned, including, but not limited to, baseball and softball diamonds, soccer and football fields, golf courses, equestrian arenas/corrals, and tennis courts.

Regional Habitat Linkages – Areas of contiguous natural habitats or undeveloped land of sufficient width to facilitate the movement, migration, foraging, breeding, and dispersal of multiple wildlife or plant species between two or more *core habitat areas* (as defined in the General Plan). The *regional habitat linkages* within the Regional Habitat Linkage (RHL) overlay zone include the Sierra Madre – Castaic Connection, the Santa Monica – Sierra Madre Connection, and the Ventura and Santa Clara River linkages. The *regional habitat linkages* areas are mapped in the County Resource Management Agency's Geographic Information System.

Security Lighting – A *luminaire* that is primarily intended to deter or detect intrusions or other unwanted activity. It can also be used to allow safe passage.

Surface Water Feature - Waters depicted on the *National Wetlands Inventory Dataset*, as amended. Data consists of mapped wetlands and riparian areas. Artificially created freshwater ponds, lakes, and agricultural water impoundments are excluded from this definition because their primary purpose is typically agriculture or water supply, they provide marginal habitat value, and they are not essential to the objectives of the regulations of this ordinance. Buffer distances are measured from the furthest extent of both the mapped wetland and riparian areas.

United States Fish and Wildlife Service National Wetlands Inventory Dataset – The United States Fish and Wildlife Service National Wetlands Inventory is a publicly available spatial data set published by the United States government that provides information on the abundance, characteristics, and distribution of U.S. wetlands. The layer specifically includes the California Wetlands Geodatabase, which contains both a Wetlands and a Riparian layer. For the purposes of this definition, artificially created freshwater ponds, lakes, and agricultural water impoundments are excluded because their primary purpose is typically agriculture or water supply, they provide marginal habitat value, and they are not essential to the objectives of the regulations of this ordinance.

Uplighting – A *luminaire* placed or designed to illuminate upward.

Vegetation – Other than landscaping associated with legally permitted development, the term *vegetation* includes native and nonnative trees and plant communities (e.g., grassland, coastal scrub, riparian vegetation, chaparral), including *invasive plants*. For purposes of this definition, commercial agricultural products are excluded.

Wildlife Crossing Structures – *Structures* that allow animals to cross human-made barriers safely, such as culverts, bridges, and underpasses. Cattle guards are not considered *wildlife crossing structures*.

Wildlife Impermeable Fencing - *Fencing* that prevents various species of wildlife (including amphibians, reptiles, mammals, birds), from freely passing through a *fence* with little or no interference. Examples of *wildlife impermeable fencing* include wrought iron, plastic mesh,

woven wire, razor wire, chain link, electric fencing, and solid walls and *fences*. Retaining walls are excluded from this definition.

Section 2

ARTICLE 3 – ESTABLISHMENT OF ZONES, BOUNDARIES AND MAPS

Article 3, Section 8103-0, Purpose and Establishment of Zones and Minimum Lot Areas, of the Ventura County Ordinance Code is hereby amended to add the Regional Habitat Linkages (RHL) overlay zone and the Critical Wildlife Passage Area (CWPA) overlay zone to read as follows:

Overlay Zones

Scenic Resource Protection	/SRP	Not Applicable
Mineral Resource Protection	/MRP	Not Applicable
Community Business District	/CBD	Not Applicable
Regional Habitat Linkages	/RHL	Not Applicable
Critical Wildlife Passage Area	/CWPA	Not Applicable

Section 3

ARTICLE 4 – PURPOSES OF ZONES

Article 4- PURPOSES OF ZONES, Section 8104-7 – Overlay Zones, of the Ventura County Ordinance Code is hereby amended by adding a new **Section 8104-7.7 – Regional Habitat Linkages Overlay Zone**, and a new **Section 8104-7.8 – Critical Wildlife Passages Area Overlay Zone**, to read as follows:

Sec. 8104-7.7 – Regional Habitat Linkages (RHL) Overlay Zone

The general purpose of the *RHL overlay zone* is to preserve *functional connectivity* for wildlife and *vegetation* throughout mapped areas defined as *regional habitat linkages* by minimizing direct and indirect barriers, minimizing loss of *vegetation* and habitat fragmentation and minimizing impacts to those areas that are narrow, impacted or otherwise tenuous with respect to wildlife movement. More specifically, the purposes of the *RHL overlay zone* include the following:

- a. Minimize the indirect impacts to wildlife created by *outdoor lighting*, such as disorientation of nocturnal species and the disruption of mating, feeding, migrating, and the predator-prey balance.

- b. Preserve the *functional connectivity* and habitat quality of *surface water features*, due to the vital role they play in providing refuge and resources for wildlife.
- c. Protect and enhance *wildlife crossing structures* to help facilitate safe wildlife passage.
- d. Minimize the introduction of *invasive plants*, which can increase fire risk, reduce water availability, accelerate erosion and flooding and diminish biodiversity within an ecosystem.
- e. Minimize *wildlife impermeable fencing*, which can create barriers to food and water, shelter, and breeding access to other individuals needed to maintain genetic diversity.

Sec. 8104-7.8 – Critical Wildlife Passage Area (CWPA) Overlay Zone

Within the *RHL overlay zone*, three subareas, referred to as *critical wildlife passage areas*, have been identified as particularly critical for facilitating wildlife movement due to (1) intact, native habitat or higher habitat values; 2) proximity to water bodies or ridgelines; 3) proximity of critical roadway crossings; 4) likelihood of encroachment by future development, and within which wildlife movement and plant dispersal could be easily disturbed by development; or 5) presence of undeveloped lands within a geographic location that connects core habitats at a regional scale. The purpose of the *CWPA overlay zone* is to address habitat fragmentation by siting *structures* in a *compact development* pattern within individual lots, thereby preserving more undeveloped, open areas for native plants and wildlife to move.

Section 4

ARTICLE 5 – PERMITTED USES

Article 5 Sections 8105-4 and 8105-5 – Uses and Structures by Zone, are hereby amended to read as follows:

Sec. 8105-4 - Permitted Uses in Open Space, Agricultural, Residential and Special Purpose Zones

	OS	AE	RA	RE	RO	R1	R2	RPD	RHD	TP
FENCES AND WALLS 6' HIGH OR LESS PER ART. 6 (42)	E	E	E	E	E	E	E	E	E	E
<u>Within the Regional Habitat Linkages Overlay Zone</u>	<u>Pursuant to Article 9</u>									
Over 6' High Per Art. 6 (18, 42)	△	△	△	△	△	△	△	△	△	△

Sec. 8105-5 - Permitted Uses in Commercial and Industrial Zones

	CO	C1	CPD	M1	M2	M3
FENCES AND WALLS 6' HIGH OR LESS PER ART. 6	E	E	E	E	E	E
<u>Within the Regional Habitat Linkages Overlay Zone</u>			<u>Pursuant to Article 9</u>			
Over 6' High Per Art. 6 (18)	△	△	△	△	△	△

E – Exempt; △ – Zoning Clearance

Section 5

ARTICLE 9 – STANDARDS FOR SPECIFIC ZONES AND ZONE TYPES

Article 9 – Standards for Specific Zones and Zone Types, Section 8109-4, Standards for Overlay and Special Purpose Zones, is hereby amended by adding new **Section 8109-4.8 – Regional Habitat Linkages Overlay Zone**, and **Section 8109-4.9 – Critical Wildlife Passage Area** to read as follows:

Sec. 8109 – 4.8 – Regional Habitat Linkages Overlay Zone

Sec. 8109 – 4.8.1 - Applicability

a. The abbreviated reference for the *regional habitat linkages* overlay zone when applied to a base zone shall be “RHL.” The provisions of this overlay zone are intended to apply to areas of the County depicted as *regional habitat linkages* on official RMA/GIS maps (as amended). The suffix “RHL” shall be added to the base zone covering land so identified (example: AE-40 ac/RHL) but shall have no effect on the provisions of the base zone, except as provided herein.

b. Except as provided below, the standards and procedures in this Sec. 8109-4.8 shall apply to all property in the *RHL overlay zone*, including all new construction, reconstruction, addition, modification, alteration, relocation, and replacement of *structures* or alteration of the physical site. Where a property is subject to conflicting standards of more than one overlay zone, the more restrictive standards shall apply. Land within the *RHL overlay zone*, and activities conducted on such land that meet the following criteria are exempt from the standards and requirements of the *RHL overlay zone*:

(1) Grading or excavation that involves a cumulative area of 500 square feet or smaller, or grading to improve drainage within 50 feet of any existing *structure*, not otherwise regulated by Appendix J of the Ventura County Building Code, as amended;

- (2) Restoration of land and improvements to their prior condition following floods, landslides, or natural disasters;
- (3) Construction of any *structure* pursuant to Sec. 8113-6;
- (4) Planting of crops or orchards that will be commercially sold;
- (5) Removal of agricultural crops or *vegetation* on previously cultivated agricultural land that may have been left uncultivated for up to ten years, or on land classified as "Prime," or "Statewide Importance," "Unique," of "Local Importance," or "Grazing" by the California Department of Conservation Important Farmlands Inventory;
- (6) *Vegetation* removed pursuant to a restoration plan approved by a public agency or *conservation organization*;
- (7) Removal of *vegetation* that has been intentionally planted as a landscape.
- (8) *Vegetation* modification adjacent to existing buildings as required by the Ventura County Fire Protection District (VCFPD) pursuant to VCFPD ordinances, or pursuant to a Community Wildfire Protection Plan or similar fuel modification/wildfire protection plan adopted by the VCFPD; and
- (9) *Vegetation* removed by a public agency as required by, or consistent with regulations to protect public health and safety. This includes but is not limited to *vegetation* removed to properly maintain vehicle sight distances, drainage, or flood control facilities.
- (10) Land subject to more restrictive standards established as a condition of a specific permit.
- (11) Land otherwise exempt by law.

When any development within the *RHL overlay zone* requires a discretionary permit, potential impacts to *functional connectivity* shall be evaluated and any applicable development standards contained within Sec. 8109-4.8 shall apply except as provided in Sec. 8109 – 4.8.2.

Sec. 8109 – 4.8.2 – Deviation from Standards and Requirements

- a. The Planning Director may authorize deviations from any standard or requirement of this Sec. 8109-4.8 during the processing of an application for a discretionary permit or approval. The decision to authorize each deviation must include written findings of fact supported by substantial evidence in the record establishing that the applicant's proposed deviation will be the functional equivalent of that which would otherwise be required by the applicable standard or requirement.
- b. The request shall state the circumstances and conditions relied upon as grounds for each deviation, and shall be accompanied by the following information and documentation:

- (1) Plans depicting the proposed project, identifying the location, size, height, and other physical aspects of the deviation, if requested.
- (2) A detailed description of the proposed deviation and the circumstances that justify the deviation.
- (3) Other data and information relevant to the requested deviation as may be required by the Planning Division.

Sec. 8109 – 4.8.3 – Outdoor Lighting – Purpose and Applicability

Outdoor lighting standards are intended to minimize potential impacts of light on wildlife.

Except for *outdoor lighting* that is exempt pursuant to Sec. 8109-4.8.3.2 or authorized pursuant to Sec. 8109-4.8.2, this Sec. 8109-4.8.3 shall apply as follows:

- a. The standards and requirements of Sec. 8109-4.8.3.1 and Sec. 8109-4.8.3.3 shall apply to all *outdoor luminaires*, and *luminaires* within translucent or transparent enclosed structures for agricultural operations that were installed or replaced after [ordinance effective date].
- b. In cases where any portion of a lot is outside the *RHL overlay zone*, applicable *outdoor lighting* standards shall only apply to *luminaires* located on the portion of the lot that is within the *RHL overlay zone*.
- c. Any *outdoor luminaire* installed prior to [ordinance effective date] (i.e., existing lighting) that does not comply with any standard or requirement of Sec. 8109-4.8.3.1 may remain in use for up to one year from [ordinance effective date]. Any non-compliant lighting still in place after the compliance deadline shall be turned off between 10:00 p.m. and sunrise.
- d. *Existing lighting* that is prohibited by Sec. 8109-4.8.4 shall be discontinued as of [one year from effective date].
- e. If a permitted *structure* or use requires a major modification to, or time extension of, the underlying discretionary permit, then all *outdoor lighting* within the development impacted by the permit modification or time extension shall be brought into compliance with the standards and requirements of Sec. 8109-4.8.3.

Sec. 8109 – 4.8.3.1 – Outdoor Lighting – General Standards

All *outdoor lighting* installed or replaced after [ordinance effective date] shall comply with the following standards and requirements:

- a. All *outdoor lighting* shall be *fully-shielded luminaires*, directed downward, and installed and maintained in such a manner to avoid *light trespass* beyond the property line. Lights at building entrances, such as porch lights and under-eave lights, may be *partially-shielded luminaires*.

b. Maximum Height of Lighting

- (1) *Luminaires* affixed to structures for the purposes of lighting *outdoor recreational areas* shall not be mounted higher than 15 feet above ground level. In cases where a *luminaire* is affixed to a fence, the top of the *luminaire* shall be no higher than the height of the fence.
- (2) Freestanding light fixtures used to light walkways and driveways shall use *luminaires* that are no higher than two feet above ground level.
- (3) All other freestanding light fixtures shall not exceed 20 feet above ground level, unless specified by a discretionary permit granted under this Chapter.

c. Lighting Color (Chromaticity) - The *correlated color temperature* of all *outdoor lighting* shall not exceed 3,000 *Kelvin*.

d. Maximum Lumens - All *outdoor lighting*, except that used for *security lighting*, *outdoor recreational facility lighting*, and driveway and walkway lighting shall have a maximum output of 850 *lumens* per *luminaire*, (which is approximately equivalent to the light output of a 60-watt bulb).

(1) Driveway and walkway lighting shall have a maximum output of 100 *lumens* per *luminaire* (which is approximately equivalent to the light output of a 20-watt bulb).

(2) See Sec. 8109-4.8.3.1(e) for standards regarding *security lighting*.

(3) See Sec. 8109-4.8.3.1(g) for standards regarding *outdoor recreational facility lighting*.

e. Security Lighting

(1) *Outdoor lighting* installed for *security lighting*, shall have a maximum output of 2,600 *lumens* per *luminaire*. Where the light output exceeds 850 *lumens*, *security lighting* shall be operated by motion sensor or a timer switch and shall be programmed to turn off no more than 10 minutes after activation.

(2) If *security lighting* is used within 200 feet of a mapped *surface water feature*, it shall be programmed to turn off no more than five minutes after activation. (See Sec. 8109-4.8.4 for additional standards related to *surface water features*).

(3) *Outdoor lighting* installed for *security lighting* that is not controlled by motion sensor or timer switch as specified by subsections (e) (1) & (2) above are prohibited.

(4) Agricultural uses located in the Agricultural Exclusive (AE) zone shall not be subject to the requirement for motion sensors.

f. Parking Area Lighting shall comply with the standards set forth in Sec. 8108-5.12 and is not subject to any other standard set forth in this Sec. 8109-4.8.3

g. Outdoor Recreational Area Lighting

(1) *Outdoor recreational area* lighting may exceed an output of 850 *lumens* and 3,000 *Kelvin* per *luminaire*. Lighting levels for these facilities shall not exceed those levels recommended in the Lighting Handbook available online by the Illuminating Engineering Society of North America (IESNA) for the class of play (Sports Class I, II, III or IV).

(2) In cases where *fully-shielded luminaires* would impair the visibility required for the intended recreational activity, *partially-shielded luminaires* and *directional lighting* methods may be used to reduce *light pollution*, *glare* and *light trespass*.

(3) *Outdoor recreational area lighting* shall not be illuminated between 10:00 p.m. and sunrise, except to complete an organized recreational event that is in progress as of 10:00 p.m. Exceptions include any necessary *security lighting* as specified in Sec. 8109-4.8.3.1(e), and parking area lighting as specified in Sec. 8108-5.12 operated as part of the *outdoor recreational facility*.

(4) The lighting system design (including lamps, *lumens*, *Kelvin*, etc.) and installation shall be prepared by a qualified engineer, architect or landscape architect, in conformance with this Sec. 8109-4.8.3.1(g)

(5) Applicants shall demonstrate that the proposed lighting installation is consistent with the purpose of this section and mitigates the effects of *light pollution* on adjacent undeveloped areas within the RHL overlay zone

h. Service Station Lighting: All *luminaires* mounted on or recessed into the lower surface of the service station canopy shall be *fully-shielded luminaires* and utilize flat lenses. No additional lighting is allowed on columns of the service station.

i. Wireless Communication Facilities: In addition to all other applicable standards for *wireless communication facilities* specified in Sec. 8107-45, *wireless communication facilities* (including radio and television towers) that are higher than 200 feet shall not use red-steady lights unless otherwise required by the Federal Aviation Administration (FAA). Only white strobe or red strobe lights, or red flashing LED lights shall be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (i.e., longest duration between flashes/dark phase) allowable by the FAA. To the extent feasible, light flashes emanating from a single tower shall be set (synchronized) to flash simultaneously.

j. Night lighting for Translucent or Transparent Enclosed Agriculture Structures: All night lighting within translucent or transparent enclosed structures used for ongoing agriculture or agricultural operations (e.g., greenhouses for crop production) shall use the following methods to reduce *light pollution* beginning at 10:00 p.m. until sunrise:

(1) *Fully- or partially-shielded directional lighting*; and

(2) Blackout screening for the walls and roof, preventing interior night lighting from being visible outside the structure.

Sec. 8109 – 4.8.3.2 – Outdoor Lighting – Exemptions

The following *outdoor lighting* and activities are not regulated by this section:

a. *Temporary lighting* for construction.

- b. *Temporary* emergency lighting.
- c. Lighting for *wireless communication facilities* to the extent required by the Federal Aviation Administration. (See Sec. 8109-4.8.3.1(i) for additional requirements related to *wireless communication facilities*.)
- d. *Temporary* or intermittent outdoor agricultural night lighting necessary to conduct agricultural activities, including *outdoor lighting* during weather events such as frosts.
- e. *Outdoor lighting* for signage permitted in accordance with Article 10.
- f. *Temporary seasonal or festive lighting*.
- g. *Outdoor lighting* with a maximum output of 60 *lumens* or less, including solar lights.
- h. *Temporary outdoor lighting* associated with a use authorized by this Chapter or a permit granted pursuant to this Chapter.
- i. Lighting on public and private streets.
- j. Any facility, equipment, or activity that is subject to preemptive state or federal regulations regarding lighting or illumination.

Sec. 8109 – 4.8.3.3 – Outdoor Lighting – Prohibited Lighting

- a. Permanently installed *luminaires* that blink, flash, rotate, have intermittent fading, or have strobe light illumination.
- b. *Luminaires* located along the perimeter of a lot except those used for security purposes that comply with all other applicable standards and requirements of Sec. 8109 – 4.8.3.
- c. *Uplighting* of landscapes (e.g., trees, fountains), or for aesthetic purposes (e.g., outdoor statues, buildings).

Sec. 8109 – 4.8.4 – Surface Water Features – Purpose and Applicability

The purpose of these standards is to preserve *functional connectivity* within *regional habitat linkages* and protect the habitat quality of *surface water features*. The provisions in this section shall apply to all lots in the *RHL overlay zone*.

In cases where any portion of a lot is outside the *RHL overlay zone*, applicable *surface water feature* standards shall only apply to the portion of the lot that is within the *RHL overlay zone*.

Sec. 8109 – 4.8.4.1 – Surface Water Features – General Standards

- a. Except as otherwise exempt pursuant to Sec. 8109 – 4.8.4.2, all new *structures*, not attached to an existing legally established *structure*, or all existing *structures* for which new uses are proposed, and that are within 200 feet of a *surface water feature* (also referred to herein as the *surface water feature 200-foot buffer area*), shall require a Planned Development permit. *Structures* and uses listed as exempt, or those requiring a zoning clearance in Secs. 8105-4 and

8105-5 shall require a Planning Director-approved planned development permit pursuant to this section.

b. Except as otherwise exempt pursuant to Sec. 8109 – 4.8.4.2, any *vegetation* removal conducted within a *surface water feature 200-foot buffer area* shall require a Planning Director-approved planned development permit.

c. The Planning Director or designee may approve a deviation from the *vegetation* removal standards described in (c) above. Applications for deviations shall be submitted in writing to the Planning Division. The request shall include documentation requested by the County Planning Division Biologist, including a field study report characterizing and classifying the vegetation type(s) proposed to be impacted, current photographs of the site, and any additional information requested by the Planning Director that is reasonably related to the deviation requested. A deviation request for a proposal to remove vegetation shall be granted provided that at least 60 percent of the vegetated area to be removed comprises *invasive plants*.

d. Any Planned Development permit issued pursuant to Sec. 8109 – 4.8.4.1 shall include an approved *least damaging alternative analysis*, as described in Sec. 8109-4.9.7. This analysis is in addition to any other applicable analyses required by the Initial Study Assessment Guidelines, including Initial Study Biological Assessments.

Sec. 8109 – 4.8.4.2 – Surface Water Features – Exemptions

A Planned Development permit is not required for the following:

a. Any addition to an existing legally established *structure*, or any new *accessory structure* within a mapped *surface water feature 200-foot buffer area*, provided the addition will not result in any *vegetation* modification within the *surface water feature 200-foot buffer area* required by the Ventura County Fire Protection District (VCFPD) pursuant to VCFPD ordinances, or pursuant to a Community Wildfire Protection Plan or similar fuel modification/wildfire protection plan adopted by the VCFPD.

Sec. 8109 – 4.8.5 – Wildlife Crossing Structures – Purpose and Applicability

The purpose of these standards is to protect and enhance areas near *wildlife crossing structures* to help facilitate safe wildlife crossing. These *structures* can include culverts, bridges, and underpasses, but do not include cattle guards. Standards set forth in this section apply to both highly-functional (HF) *wildlife crossing structures* and moderately-functional (MF) *wildlife crossing structures*. Both HF and MF *wildlife crossing structures* are typically at least 24 inches in diameter. A HF *wildlife crossing structure* provides a high level of potential *functional connectivity* and includes several features that support increased use by wildlife (e.g., vegetation that provides cover or habitat is present at entrances, light is visible at the opposite entrance, suitable wildlife habitat is located nearby). MF *wildlife crossing structures* provide a moderate level of potential *functional connectivity* and include fewer features that support increased use by wildlife. The locations of both HF and MF *wildlife crossing structures* are identified in RMA/GIS.

The provisions in this section shall apply to all lots in the *RHL overlay zone*. For lots that are partially within the *RHL overlay zone*, this section shall apply only to the portion of the lot within the *RHL overlay zone*.

Sec. 8109 – 4.8.5.1 – Wildlife Crossing Structures – General Standards

a. *HF Wildlife Crossing Structures*

No *vegetation* shall be removed from, and no new *structures* shall be allowed on property outside of the Caltrans or County right-of-way that is within 300 feet of the entry and exit of a *HF wildlife crossing structure* unless a Planning Director-approved Planned Development permit is approved.

b. *MF Wildlife Crossing Structures*

No *vegetation* shall be removed from, and no new *structures* shall be allowed on property outside of the Caltrans or County right-of-way that is within 100 feet of the entry and exit of a *MF wildlife crossing structure* unless a Planning Director-approved Planned Development permit is approved.

c. In cases where a *wildlife crossing structure* is located within a *surface water feature*, the largest buffer applicable to the *surface water feature*, *HF wildlife crossing structure* or *MF wildlife crossing structure*, shall be used.

d. All discretionary permits issued pursuant to this section shall include an approved *least damaging alternative analysis*, as described in Sec. 8109-4.9.7. This analysis is in addition to any other applicable analyses required by the Initial Study Assessment Guidelines, including Initial Study Biological Assessments.

e. The Planning Director or designee may approve a deviation from the *vegetation* removal standards set forth in Secs. 8109-4.8.5.1 a and b. Applications for deviations shall be submitted in writing to the Planning Division. The request shall include, documentation requested by the County Planning Division Biologist, including a field study report characterizing and classifying the vegetation type(s) proposed to be impacted, current photographs of the site, and any additional information requested by the Planning Director that is reasonably related to the deviation requested. A deviation request for a proposal to remove vegetation shall be granted provided that at least 60 percent of the vegetated area to be removed comprises *invasive plants*.

Sec. 8109 – 4.8.5.2 – Wildlife Crossing Structures – Exemptions

A planned development permit is not required for projects that are within or include a portion of land within *wildlife crossing structures* as follows:

a. Regular maintenance required to clean out soil, debris, and overgrowth, consistent with all federal, state, and local regulations and permits.

b. Any addition to an existing legally established structure, or any *new accessory structure* within 300 feet of the entry or exit of a *HF wildlife crossing structure*, or within 100 feet of the entry or exit of a *MF wildlife crossing structure*, in the event that the proposed addition will not result in any *vegetation* modification within those buffer areas pursuant to VCFPD ordinances, or pursuant to a Community Wildfire Protection Plan or similar fuel modification/wildfire protection plan adopted by the VCFPD.

Sec. 8109 – 4.8.6 – Invasive Plants – Purpose and Applicability

The purpose of this standard is to protect areas within the *regional habitat linkages* from further degradation caused by *invasive plants*.

Sec. 8109 – 4.8.6.1 – Invasive Plants – General Standard

The intentional planting of *invasive plants* is prohibited throughout the *RHL overlay zone*, except those planted as commercial agricultural crops or grown as commercial nursery stock.

Sec. 8109 – 4.8.7 – Wildlife Impermeable Fencing – Purpose and Applicability

The purpose of these standards is to limit the direct barriers created by *fencing* and to address geographic areas where the mapped *regional habitat linkages* are constrained, potentially resulting in limited wildlife movement. This section does not apply to any *fencing* installed prior to the effective date of this ordinance amendment (*existing fencing* or *existing wildlife impermeable fencing*).

In cases where any portion of a lot is outside the *RHL overlay zone*, applicable *fencing* standards, including the calculation of gross lot area required by Secs. 8109 – 4.8.7.2 and 8109 - 4.8.7.3, shall only apply to the portion of the lot that is within the *RHL overlay zone*.

Sec. 8109 – 4.8.7.1 – Wildlife Impermeable Fencing – General Standards

For purposes of Sec. 8109-4.8.7, an enclosure is defined as 1) an area that is entirely surrounded by a wall or *fence*, or 2) an area that operates as a functional enclosure due to a wall or fence. Except for gates and associated gate support components, any portion of a new or replacement fence, which forms an enclosure and includes one or more of the following design features shall be considered *wildlife impermeable fencing*:

- a. Any fence that is higher than 60 inches above grade, unless otherwise exempt pursuant to Sec. 8109-4.8.7.4. This includes any wire strands that are placed above a top rail of a fence.
- b. Electric *fences* comprised of any material or number of electrified strands. Electric *fences* are not allowed in Urban Residential Zones, pursuant to Sec. 8106-8.1.3.
- c. Wrought iron, plastic mesh, woven wire, razor wire, chain link, and any solid wall (e.g., brick, cinderblock) or *fence* (e.g., wood or vinyl).

Sec. 8109 – 4.8.7.2 – Wildlife Impermeable Fencing – Ministerial Permit

a. On lots zoned as Open Space (OS) or Agricultural Exclusive (AE), *wildlife impermeable fencing* not exempt pursuant to Sec. 8109-4.8.7.4 may be permitted with a Zoning Clearance provided that the following standards are met:

(1) Except as otherwise required by this section, *fences* shall be consistent with current *fence* standards in Article 6 (Sec. 8106-8.1); and

(2) For lots with no *existing wildlife impermeable fencing*, the cumulative area enclosed by the proposed *fencing* shall not exceed ten percent of the gross lot area; or

(3) For lots with *existing wildlife impermeable fencing* the cumulative area enclosed by the proposed *fencing* shall not exceed ten percent of the gross lot area, excluding the cumulative area already enclosed by *existing wildlife impermeable fencing*.

(4) A *fencing* site plan shall be provided to the Planning Division that includes information about the type, design, and location of all *existing fencing* on the subject lot, including calculations for the area of each *existing fence enclosure*.

Sec. 8109 – 4.8.7.3 – Wildlife Impermeable Fencing – Discretionary Permit

a. On lots zoned Open Space (OS) or Agricultural Exclusive (AE), *wildlife impermeable fencing* not otherwise exempt pursuant to Sec. 8109-4.8.7.4, or subject to a ministerial permit pursuant to Sec. 8109-4.8.7.2, shall not be constructed without, or be inconsistent with, a planned development permit approved pursuant to this section.

b. An application for a planned development permit for proposed *wildlife impermeable fencing* that meet either criteria in Secs. 8109-4.8.7.3.b (1) or (2) below shall include a *fencing* site plan. The *fencing* site plan shall include information depicting the type, design, and location of all *existing* and proposed *fencing* on the subject lot, including calculations for the area of each *fence* enclosure.

(1) For lots with no *existing wildlife impermeable fencing*, the cumulative area enclosed by the proposed *fencing* is greater than ten percent; or

(2) For lots with *existing wildlife impermeable fencing*, the cumulative area enclosed by the proposed *fencing* is greater than ten percent of the gross lot area excluding the cumulative area already enclosed by *existing wildlife impermeable fencing*.

c. An application for a planned development permit for *wildlife impermeable fencing* pursuant to Secs. 8109-4.8.7.3 b (1) or (2) shall include an approved *least damaging alternative analysis*, as described in Sec. 8109-4.9.7. This analysis is in addition to any other applicable analysis required by the *Initial Study Assessment Guidelines*, including the *Initial Study Biological Assessments*.

d. In all zones, any *fence* installed or replaced as part of a new discretionary permit or major permit modification shall be reviewed as part of the whole discretionary entitlement to minimize impacts to wildlife movement.

e. A planned development permit shall not be granted unless a finding can be made that the configuration of any proposed *wildlife impermeable fencing* will not substantially impede wildlife from moving through the remaining connected undeveloped areas within the regional habitat linkages areas. Criteria for making this determination shall be based on the size and configuration of proposed *wildlife impermeable fencing* areas. It shall also take into account the configuration of existing development, areas that provide potential habitat, landscape features that could facilitate wildlife movement such as riparian corridors or ridgelines, major barriers such as freeways, and other undeveloped areas that could facilitate wildlife movement. This analysis shall also consider movement of wildlife at a range of spatial scales, including local scales and movements of hundreds of feet up to regional scales which could include movements of tens of miles.

Sec. 8109 – 4.8.7.4 – Wildlife Impermeable Fencing – Exemptions

A planned development permit is not required for the following activities conducted within the RHL overlay zone:

- a. Any *existing wildlife impermeable fencing*.
- b. Any *wildlife impermeable fencing* that is required by any federal or state law or local regulation.
- c. Any *wildlife impermeable fencing* necessary to enclose commercially grown agricultural products. For purposes of this section, commercially grown agricultural products are defined as any plant product (including food, plant fiber, feed, ornamentals, or forest), that will be commercially sold.
- d. Any *wildlife impermeable fencing* that is required to protect public health and safety as determined by a regulatory agency. This includes any *wildlife impermeable fence*, or portion thereof, installed as an outdoor swimming pool barrier, provided it meets the requirements of the Ventura County Building Code and does not extend more than 50 feet from the edge of the outdoor swimming pool.
- e. On lots zoned as Open Space (OS) and Agricultural Exclusive (AE), any *wildlife impermeable fencing* within 50 feet from the exterior walls of any dwelling or a principal *structure* related to agriculture, provided it is otherwise consistent with existing *fencing* standards included in Sec. 8106-8.1.
- f. Any *wildlife impermeable fencing* used to enclose a water well or pump house, provided the enclosure allows for clearance of up to a maximum of 10 feet from the water well or pump house infrastructure and does not enclose more than 500 square feet.

- g. Any *wildlife impermeable fencing* installed by or for a public agency, including Caltrans and the Ventura County Public Works Agency for the sole purpose of restricting wildlife from entering a road right-of-way or directing wildlife toward road crossing *structures*.
- h. *Wildlife impermeable fencing* or wall spans that do not form an enclosure.
- i. Any *wildlife impermeable fencing* used for habitat protection/restoration by a *conservation organization*, or public agency when specified by a habitat preservation plan or habitat restoration plan approved by a public agency.
- j. In Open Space (OS) and Agricultural Exclusive (AE) zones, any *wildlife impermeable fencing* on lots with an area of 10,000 square feet or less, notwithstanding subsection f.

Sec. 8109 – 4.8.7.5 – Wildlife Impermeable Fencing – Prohibited Fences

The following *wildlife impermeable fencing* is prohibited:

- a. *Wildlife impermeable fencing* on any lot that has no *principal use* or *structure*.
- b. *Wildlife impermeable fencing* around the perimeter of a lot, unless otherwise exempt.

Sec. 8109 – 4.9 – Critical Wildlife Passage Area Overlay Zone

Sec. 8109 – 4.9.1 - Application

The abbreviated reference for the *critical wildlife passage areas* overlay zone when applied to a base zone shall be “CWPA.” The provisions of the *CWPA overlay zone* are intended to apply to areas of the County depicted as *critical wildlife passage areas* on official RMA/GIS maps (as amended). *Critical wildlife passage areas* cover portions of land within the *regional habitat linkage areas* overlay zone as depicted on official RMA/GIS maps (as amended). The suffix “CWPA” shall be added to the base zone covering land so identified (example: RA-40 ac/RHL/CWPA), but shall have no effect on the provisions of the base zone, except as provided herein. Except as noted in Sec. 8109-4.9.6, the provisions of this section shall apply in all *critical wildlife passage areas* to any *structure*, use, or *wildlife impermeable fencing*, on lots meeting the following zoning and size criteria:

- a. Lots zoned Open Space (OS), Agricultural Exclusive (AE), Commercial (CPD), Industrial (M1, M2, or M3), or Timber Preserve (TP) and larger than one acre; or
- b. Any proposed *structure* or use on vacant lots zoned as Residential (RA, RE, RO, R1, R2, RPD, RHD) that are larger than one acre; or
- c. Any addition to any *existing structure* or modification to any existing use on lots zoned as Residential (RA, RE, RO, R1, R2, RPD, RHD) that are larger than two acres.

Sec. 8109 – 4.9.2 – Deviation from Standards and Requirements

a. The Planning Director may authorize deviations from any standard or requirement of this Sec. 8109-4.8 during the processing of an application for a discretionary permit or approval. The decision to authorize each deviation must include written findings of fact supported by substantial evidence in the record establishing that the applicant's proposed deviation will be the functional equivalent of that which would otherwise be required by the applicable standard or requirement.

b. The request shall state the circumstances and conditions relied upon as grounds for each deviation, and shall be accompanied by the following information and documentation:

(1) Plans depicting the proposed project, identifying the location, size, height, and other physical aspects of the deviation, if requested.

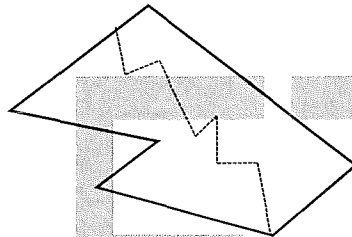
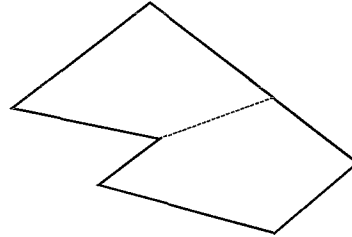
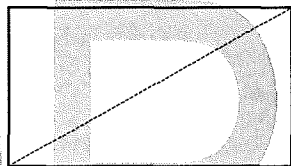
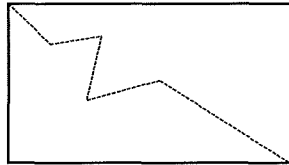
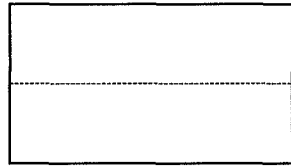
(2) A detailed description of the proposed deviation and the circumstances that justify the deviation.

(3) Other data and information relevant to the requested deviation as may be required by the Planning Division.

Sec. 8109 - 4.9.3 – Compact Development –Siting Standard

Subject to Sec. 8109-4.9.4 or Sec. 8109-4.9.5, any proposed *structure* or use that meets any one of the criteria set forth in Sec. 8109-4.9.1 shall be sited exclusively in one of the two contiguous areas created by a line bisecting a single lot into two sections of equal areas (halves). The bisecting line may consist of a single, straight line segment or a series of connected, non-intersecting line segments that do not form a straight line. Each of the two endpoints of a bisecting line shall coincide with any two lot boundary lines. As part of the Planning Division application for any structure or use for which a ministerial permit is required pursuant to Sec. 8109-4.9.4, or a discretionary permit is required pursuant to Sec. 8109-4.9.5, a site plan shall be submitted which shows the location, length, and orientation of each segment of the bisecting line. The site plan shall be drawn to scale and shall identify the area in square feet of each section of land on either side of the bisecting line. If any existing *structure* or use is present within both halves, any new *structure* or use must be sited in the half with the largest relative cumulative area of existing building coverage. Once the location of the bisecting line for a lot is approved by the Planning Division, it shall not be modified and shall be the basis of siting any future *structure* or use pursuant to this section.

Example Illustrations of Lines Bisecting Lots into Two Sections of Equal
Area
Section 8109-4.9.3



Sec. 8109 – 4.9.4 – Compact Development – Ministerial Permit

Except those *structures* or uses that otherwise require a discretionary permit pursuant to Secs. 8105-4 and 8105-5, a zoning clearance shall be required for any new *structure* or use that meets any one of the criteria set forth in Sec. 8109-4.9.1, and that complies with any of the following:

- a. The siting standard set forth in Sec. 8109-4.9.3; or
- b. Located within 50 feet of an existing legally established *structure*, use, public road or street, or driveway; or
- c. Located within 50 feet of an agricultural access road necessary to support the production of *commercially grown agricultural products*. For purposes of this section, *commercially grown agricultural products* are defined as any plant or animal agricultural product (including food, feed, fiber, ornamentals, or forest), that will be commercially sold, including livestock raised for commercial production.

Sec. 8109 – 4.9.5 – Compact Development – Discretionary Permit

A Planning Director-approved planned development permit, including a *least damaging alternative analysis* pursuant to Sec. 8109-4.9.7, shall be required for any *structure* or use described in Sec. 8109-4.9.1 that does not comply with the standards set forth in Sec. 8109-4.9.4.

Sec. 8109 – 4.9.6 – Compact Development – Exemptions

Sec. 8109-4.9 shall not apply to the following:

- a. Lots where only a portion lies within the *CWPA overlay zone*.
- b. Any *structure* or use on property zoned commercial (CO, C1, CPD) or industrial (M1, M2, or M3).
- c. Grading or excavation within 50 feet of an existing *structure* to improve drainage.
- d. Planting of crops and orchards that will be commercially sold.

Sec. 8109 – 4.9.7 – Least Damaging Alternative Analysis

a. The purpose of the *least damaging alternative analysis* is to identify and select project design alternatives that minimize the direct and indirect adverse impacts on biological resources, such as wildlife habitat that potentially support wildlife movement. The objective of the *least damaging alternative analysis* is to provide a reasonable range of options from which to select a development proposal that minimizes these impacts to wildlife movement and habitat connectivity to the greatest extent practicable.

b. The *least damaging alternative analysis* shall evaluate the proposed development with respect to the biological resources both on and near the site, including, but not limited to, undeveloped areas, areas with *vegetation*, crossing *structures*, drainages, and ridgelines.

c. The *least damaging alternative analysis* does not take the place of an Initial Study Biological Assessment (ISBA). If a *least damaging alternative analysis* is required, it shall be completed in addition to an ISBA. The *least damaging alternative analysis* shall be prepared in consultation with the County Planning Division Biologist. The *least damaging alternative analysis* shall include some or all the following elements, as determined by the County Planning Division Biologist:

(1) Written description and graphic depiction of project design alternatives on a site plan that meets the purpose of the *least damaging alternative analysis*, as determined by the County Planning Division Biologist. The description shall include mapped biological resources, including all applicable *vegetation* community types (e.g., coastal sage scrub, chaparral). A description and photographs of all biological resources on the property shall be provided by request of the County Planning Division Biologist. Project design alternatives may include different building site

locations, different *structure* sizes/locations within the building site, and related fuel modification zones, driveway/access roads, location, extent and description of all *wildlife impermeable fencing*, and water/wastewater system locations;

(2) A table that includes comparative data for project design alternatives, such as cubic yards of cut/fill for grading and acres of impacts on the resource area (e.g., *surface water features* and buffers, *vegetation*, and land within the *RHL overlay zone*);

(3) Written summary explaining how the proposed project elements and design will protect *functional connectivity* of the *RHL overlay zone*. Project elements may include *compact development* to the maximum extent feasible both within the site, and with respect to offsite development. The summary shall also provide detailed information on why proposed alternatives are not the least damaging alternative. The summary shall also include consideration and determination of any alternatives suggested by the County Planning Division Biologist.

(4) Other data or information relevant to the least damaging alternative analysis as may be required by the County Planning Division Biologist.

d. The Planning Director or designee shall review and approve the design alternatives, and approval shall be based on an analysis of the following criteria:

(1) That the establishment or maintenance of the proposed development or use will not significantly reduce, restrict or adversely affect biological resources that have the potential to support wildlife movement. Biological resources considered during impact analysis shall include, but are not limited to, *vegetation*, wetlands and water features, ridgelines, and areas in and adjacent to roadway crossings. Impacts that will be considered include, but are not limited to, habitat and open space fragmentation and creation of new direct or indirect barriers;

(2) That *structures* will be sited to minimize developed land in such a way as to provide the largest possible contiguous undeveloped portion of land that avoids impacts to biological resources;

(3) That *wildlife impermeable fencing* configuration will be sited to minimize impacts to wildlife movement;

(4) That other uses proposed for the lot will not significantly reduce, restrict or adversely affect biological resources that have the potential to support wildlife movement on-site or in the area; and

(5) That the development or use will be sited to remove as little land containing biological resources that have the potential to support wildlife movement as possible.

**Section 6
Severability**

If any subsection, sentence, clause, phrase or word of the Ordinance is for any reason held to be invalid by a court of competent jurisdiction, such decisions shall not affect the validity of the remaining portions of this Ordinance. The Ventura County Board of Supervisors hereby declares that it would have passed and adopted this Ordinance, and each and all provisions hereof, irrespective of the fact that one or more provisions may be declared invalid.

**Section 7
Effective Date; Implementation**

This Ordinance shall become effective 30 days after adoption.

PASSED AND ADOPTED this xxth day of xxx, 2018 by the following vote:

AYES: _____ Supervisors _____

NOES: _____

ABSENT: _____

CHAIR, BOARD OF SUPERVISORS

ATTEST:

MICHAEL POWERS

Clerk of the Board of Supervisors

County of Ventura, State of California

By _____

Deputy Clerk of the Board

Exhibit 4
**Summary of Regulations of Ventura County Cities Related to Habitat Connectivity
and Wildlife Movement**

City of Simi Valley – The City of Simi Valley has the greatest portion of incorporated land located within the mapped corridor with estimates of over 7,500 acres. In Simi Valley the corridor passes through a large portion of the southern and western parts of the City. It also transects the eastern city boundary and runs along the fringes of the northeastern boundary. The City of Simi Valley has a recently updated General Plan (2012). The Natural Resources section, includes strong goals and policies that specifically prioritize protection of wildlife corridors and natural habitat. In addition, the City uses the South Coast Missing Linkages project mapping to identify regional wildlife corridors which are included as a “Wildlife Habitat and Movement Corridors” map in the 2030 General Plan. However, there are no standards in the City’s zoning ordinance that address wildlife movement. Each proposed development is considered on a case-by-case basis during discretionary project review.

City of Thousand Oaks/COSCA – The City of Thousand Oaks has the second largest portion of land within the corridor estimated at over 5,600 acres. According to the City’s recently updated Conservation Element (2013), the Thousand Oaks Planning Area contains approximately 15,000 acres of natural open space. The City’s Conservation and Open Space Elements contain many policies directed at the protection of wildlife habitat and movement corridors and acknowledge the South Coast Missing Linkages project (2006) mapped wildlife corridors. Land designated Open Space in the City’s General Plan is intended to be preserved in an open, natural and undeveloped state. In addition, Open Space designated land policies include provisions that state the land shall be retained as open space in perpetuity and that natural open space land should be transferred to public ownership to provide consistent management, linkages with other components of the open space system and appropriate recreational and educational opportunities. The Conservation Element identifies that the acquisition of additional land identified as Open Space in the General Plan should occur in order to complete vital habitat linkages and provide access by wildlife to these resources.

Finally, land that is designated Open Space and under the ownership of Conejo Open Space Conservation Agency (COSCA) cannot be re-designated without a vote of the people. COSCA was created in 1977 and is a joint powers agreement between the City of Thousand Oaks and the Conejo Recreation and Park District. COSCA’s purpose is to preserve, protect and manage open space resources in the Conejo Valley (also defined as the Thousand Oaks Planning Area). COSCA currently owns or manages 15,194 acres of open space and maintains more than 150 miles of trails.

In Thousand Oaks, the majority of the land within the corridors is also within COSCA’s purview except for along the very northern tip of the City. This area is bisected by Highway 23 and located in an important part of the corridor. The City’s General Plan designations includes a mix of Open space and low density residential.

City of Moorpark – The City of Moorpark contains approximately 768 acres of land within the corridor. The corridor primarily passes along the eastern edge adjacent to the Simi Valley boundary in the easternmost area and adjacent to the County along the southeastern edge. Highway 23 bisects the corridor twice within the City boundary. There is also one very narrow passage through the center of the City. The City contains two General Plan policies aimed at protection of ecologically sensitive habitats and maintaining wildlife corridors. These policies are implemented through development and environmental review of discretionary development projects. These areas are further protected by conservation easements or Open Space zoning. However, there are development projects that have already been approved that threaten the narrow passage, or chokepoint, that passes directly through the City boundary. Generally, the Highways 23 and 118 crossings are the most important and impacted chokepoint locations in the City of Moorpark. Although there is one box culvert crossing under Highway 118 in the City and a second crossing at Alamos Canyon near Simi Valley, these remain critical chokepoints.

City of Santa Paula - The City of Santa Paula contains approximately 400 acres of land within the corridor. The wildlife corridor primarily passes through the City in, and adjacent to, the Santa Clara River and Santa Paula Creek. The Santa Paula General Plan recognizes and provides objectives that call out habitat and wildlife corridors as "...natural resources that should be managed, protected, conserved, reclaimed and used wisely...". The General Plan also contains several goals for the protection of biological resources including, native woodlands, riparian habitat and wildlife habitat. Potential impacts of development are evaluated in accordance with CEQA through the discretionary review process.

City of Camarillo – The City of Camarillo contains approximately 338 acres of land within the corridor. The wildlife corridors transect Camarillo's boundary in the southeast corner of the City adjacent to the Thousand Oaks city boundary. Although the City's General Plan does not contain specific policies that address wildlife corridors, open space designated areas are intended to be conserved or preserved for the production of food and fiber, for the enjoyment of scenic beauty, for recreation, and for the use of natural resources. The General Plan contains policies directed at the preservation of natural plant and animal habitat. Potential impacts of development are evaluated in accordance with CEQA through the discretionary review process.

City of Fillmore - The City of Fillmore contains approximately 119 acres of land within the corridor. The wildlife corridor primarily passes through the City in, and adjacent to, the Santa Clara River. The wildlife corridor also follows the City's western boundary along Sespe Creek. The wildlife corridor parallels, but is not directly adjacent to, the eastern City boundary. The City's General Plan (1988) contains a Significant Habitat Overlay that requires a buffer from development to protect these resources. The Open Space zoning also serve to protect biological resources from impacts of development. Potential impacts of development are evaluated in accordance with CEQA through the discretionary review process.

City of Ojai – The City of Ojai contains approximately 562 acres of land within the corridor. The wildlife corridors run parallel along the northern and southern boundaries of the City in wide bands. Due to the large expanses of corridor area north and south of the

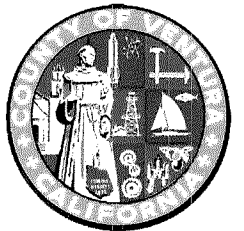
City of Ojai, urban development does not present as significant a threat to the wildlife movement and habitat. The City of Ojai's General Plan places great value on the surrounding natural environment.

City of Ventura – The City of Ventura contains approximately 391 acres of land within the proposed corridor. The wildlife corridor primarily runs along the Ventura River. This linkage was added to the corridor by Ventura County staff and is not a part of the South Coast Missing Linkages project. The Santa Clara River corridor borders the City of Ventura to the south/southeast but transect very little of the City. The City's General Plan provides policies that are aimed at protecting and preserving the natural environment, including native plants and animals. Potential impacts of development are evaluated in accordance with CEQA through the discretionary review process.

Note: The cities of Oxnard and Port Hueneme do not contain mapped wildlife corridors.

Regional Habitat Linkages Project

STAKEHOLDER GROUP PRESENTATION – AUGUST 14, 2018
VENTURA COUNTY PLANNING DIVISION



Project Purpose and Intent

The purpose of the project is to preserve and enhance habitat connectivity, which is characterized by the degree to which regional landscapes, encompassing a variety of natural, semi-natural, and developed areas, are conducive to wildlife movement and to sustain ecological processes.

The intent of the project is to ensure that development is designed and constructed to allow wildlife and plant species to move or migrate between natural lands, while protecting individual property rights.

Project Objectives

Based on January 2017 Board action, General Plan policies and zoning standards were developed to address four project objectives:

- ❖ Minimize Indirect Barriers
- ❖ Minimize Direct Barriers
- ❖ Minimize Vegetation Loss and Habitat Fragmentation
- ❖ Protect/Enhance Chokepoints

Draft General Plan Amendment

- ❖ Adds Regional Habitat Linkages discussion to Biological Resources Section (Section 1.5 of Goals, Policies, Programs)
- ❖ Adds Regional Habitat Linkages Map and Critical Wildlife Passage Areas Maps
- ❖ Adds policy stating that development within the Habitat Linkages are subject to provisions and standards of Regional Habitat Linkages Overlay Zone in the Non-Coastal Zoning Ordinance

Regional Habitat Linkages Ordinance

Creates Two Overlay Zones in the Non-Coastal Zoning Ordinance:

- ❖ Regional Habitat Linkages (RHL) Overlay Zone
- ❖ Critical Wildlife Passage Areas (CWPA) Overlay Zone

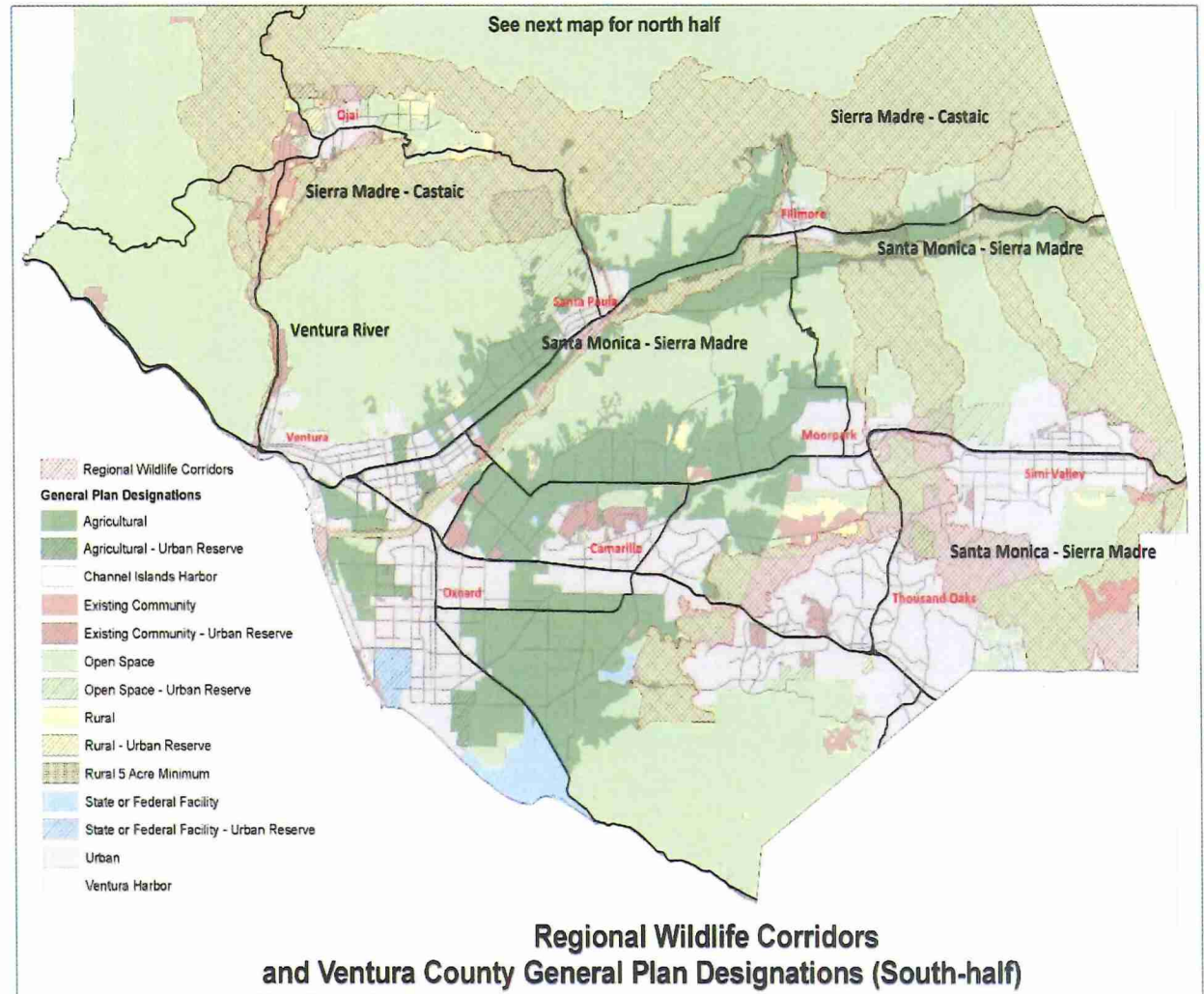
Regional Habitat Linkages Overlay Zone

Corridors in South-half:

- Santa Monica – Sierra Madre
- Sierra Madre- Castaic
- Ventura River

Integrated into Initial Study Assessment Guidelines (ISAGs)

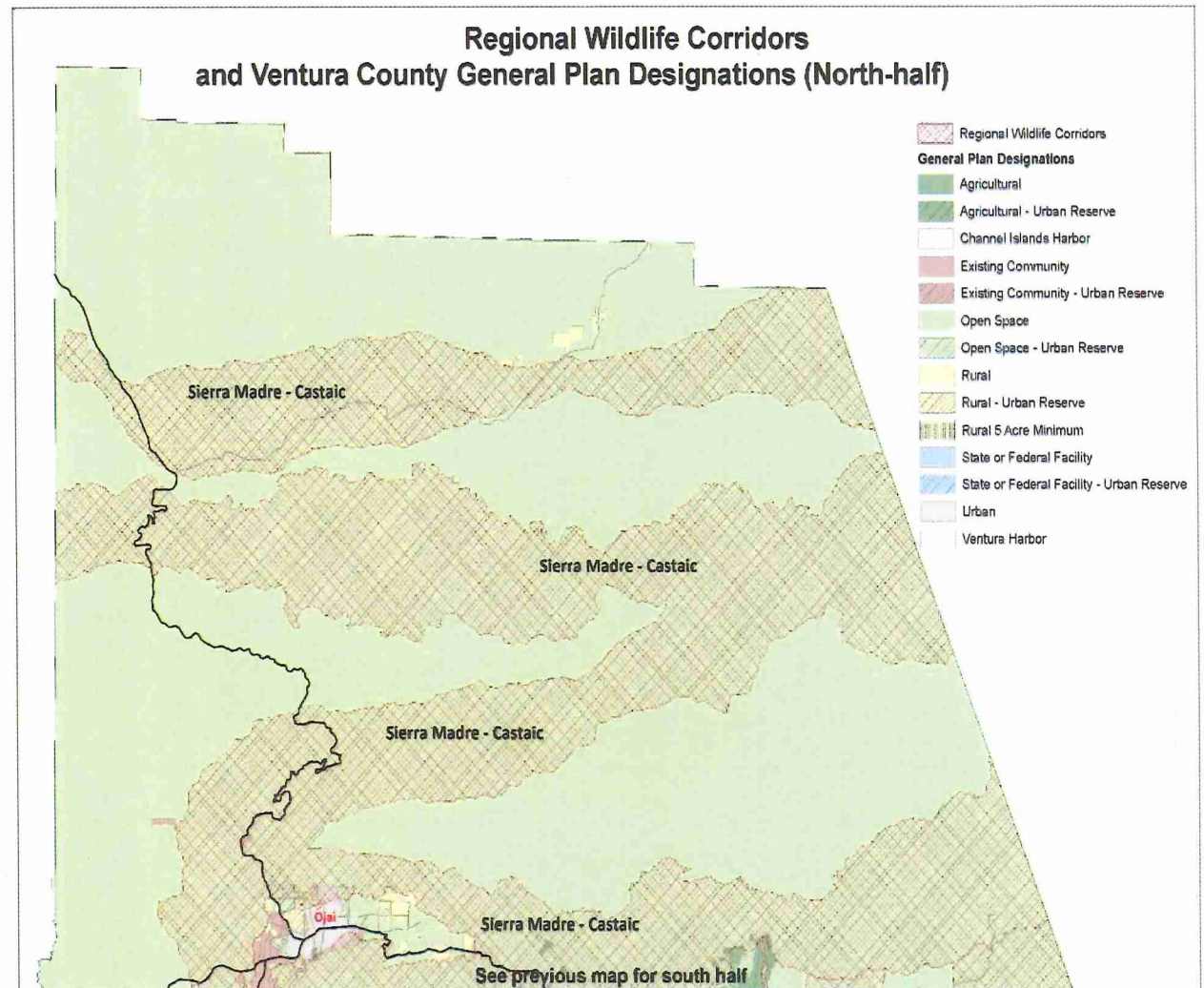
North/south corridors are considered the most vulnerable



Regional Habitat Linkages Overlay Zone

Corridor in North-half of the County includes Sierra Madre- Castaic

Integrated into Initial Study Assessment Guidelines (ISAGs)



Regional Habitat Linkages (RHL) Overlay Zone Development Regulations

- ❖ Outdoor night-time lighting (Minimize Indirect Barriers)
- ❖ Buffers around Surface Water Features (Minimize vegetation loss and fragmentation of habitat)
- ❖ Buffers around Wildlife Crossing Structures (Minimize vegetation loss and fragmentation of habitat)
- ❖ No intentional planting of invasive species (Minimize vegetation loss)
- ❖ Limits on Impermeable Fencing (Minimize Direct Barriers)

RHL Overlay Zone Regulations

Outdoor Night-Time Lighting - § 8109 – 4.8.3

- ❖ Generally consistent with Dark Sky Ordinance (PC recommended approval on 7/26/18)
- ❖ Applies to new and replacement lighting
- ❖ Existing, nonconforming lighting does not need to be replaced for one year, after which it must be turned off between 10:00 p.m. and sunrise.
- ❖ Fully-shielded; downward facing; limited output of 850 lumens per luminaire; controlling for “color temperature.”

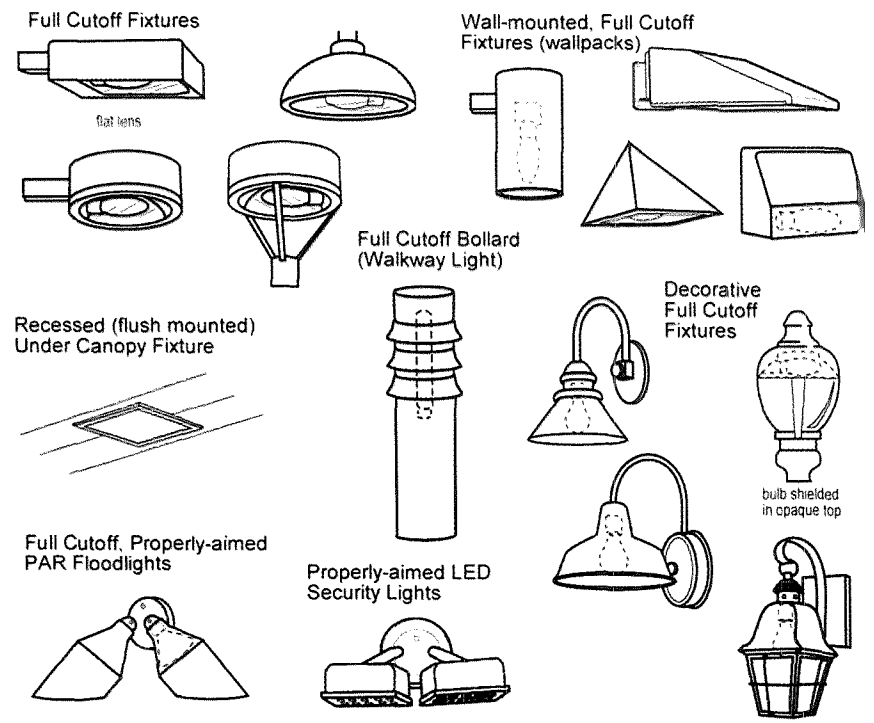
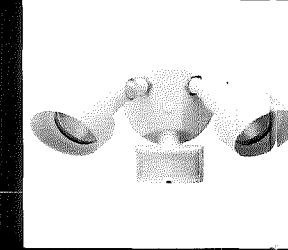
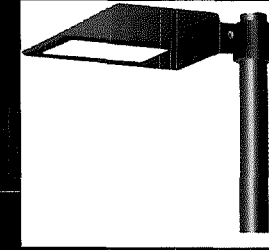
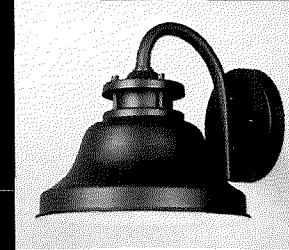
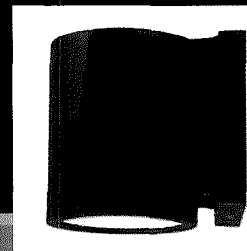
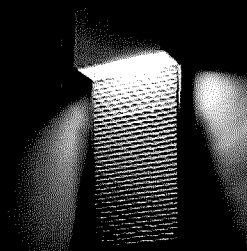
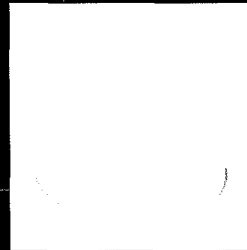
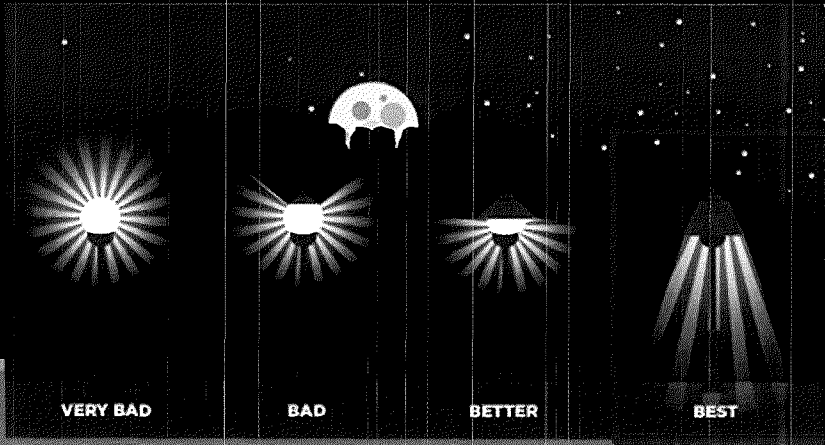
RHL Overlay Zone Regulations

Outdoor Night-Time Lighting - § 8109 – 4.8.3

- ❖ Brighter security lighting (2,600 lumens) allowed if on motion sensor
- ❖ Requires techniques for blocking light from greenhouses after 10:00 p.m.
- ❖ Walkway and driveway lighting is limited to 100 lumens per luminaire
- ❖ Includes regulations for public and private recreation facilities
- ❖ Perimeter lighting prohibited; No new uplighting for aesthetic purposes

Fully-Shielded Luminaires

A luminaire constructed and installed in such a manner that ALL light emitted by the fixture is projected below the horizontal plane through the fixture's lowest light-emitting part.

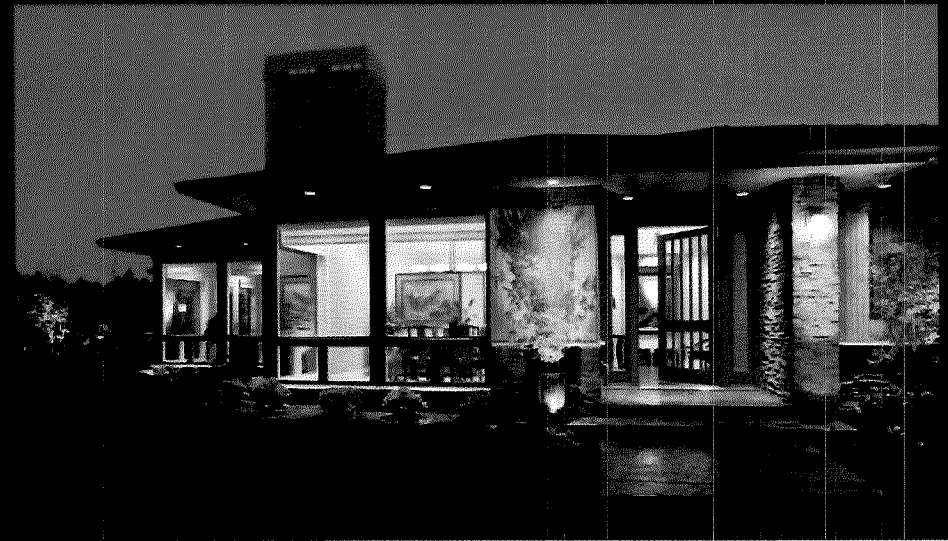


Fully-Shielded Luminaires



Partially-Shielded Luminaires

- ◆ Porch lights and under-eave lights may be *partially-shielded*



KELVIN

(CORRELATED COLOR TEMPERATURE)

2700K

Warm White

- 2700-3000K
- Most similar to incandescents
- Inviting, relaxing

3000K

Bright White

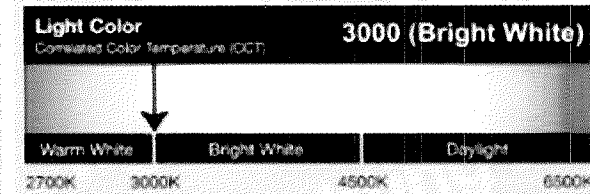
- 3500-4100K
- Energetic, lively
- Good for kitchens workspaces

lighting facts^{CM}

A Program of the U.S. DOE

Light Output (Lumens)	850
Watts	18
Lumens per Watt (Efficacy)	47

Color Accuracy	85
Color Rendering Index (CRI)	



All results are according to IESNA LM-79-2008: Approved Method for the Electrical and Photometric Testing of Solid-State Lighting. The U.S. Department of Energy (DOE) verifies product test data and results.

Visit www.lightingfacts.com for the Label Reference Guide.

Registration Number: R3114-Y21508

Model Number: DFN 38 WW FL 120

Type: Replacement lamp

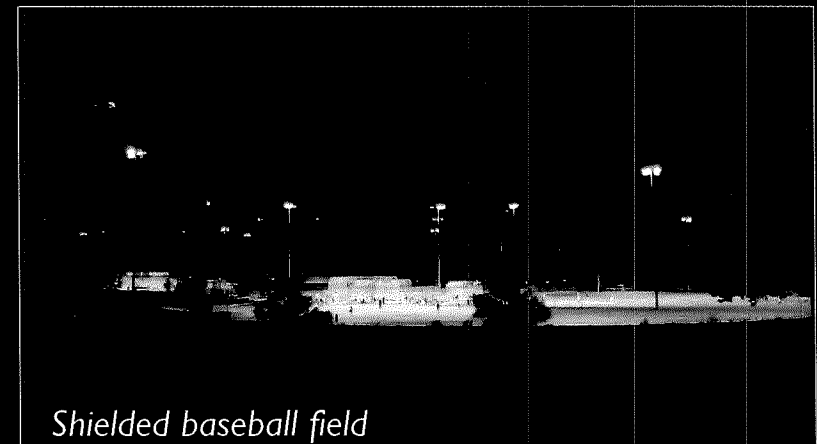
6500K

CORRELATED COLOR TEMPERATURE (CCT) LUX

Outdoor Recreational Facility Lighting

Public and Private

- ◇ Use appropriate lighting levels in the Lighting Handbook by IESNA (*i.e. can be higher than 850 lumens and 3000 K*)
- ◇ Use *partially-shielded luminaires* and employ *directional lighting* methods
- ◇ No lighting between 10:00 p.m. to 6:00 a.m., unless to complete play



RHL Overlay Zone Regulations

Outdoor Night-Time Lighting

Exemptions:

- ❖ Temporary/intermittent agriculture uses that require outdoor night lighting
- ❖ Short-term lighting authorized by a temporary use permit
- ❖ Legal, permitted signage
- ❖ Public rights of way
- ❖ Emergency lighting
- ❖ Lighting subject to preemptive state or federal standards
- ❖ Temporary Seasonal/festive lighting

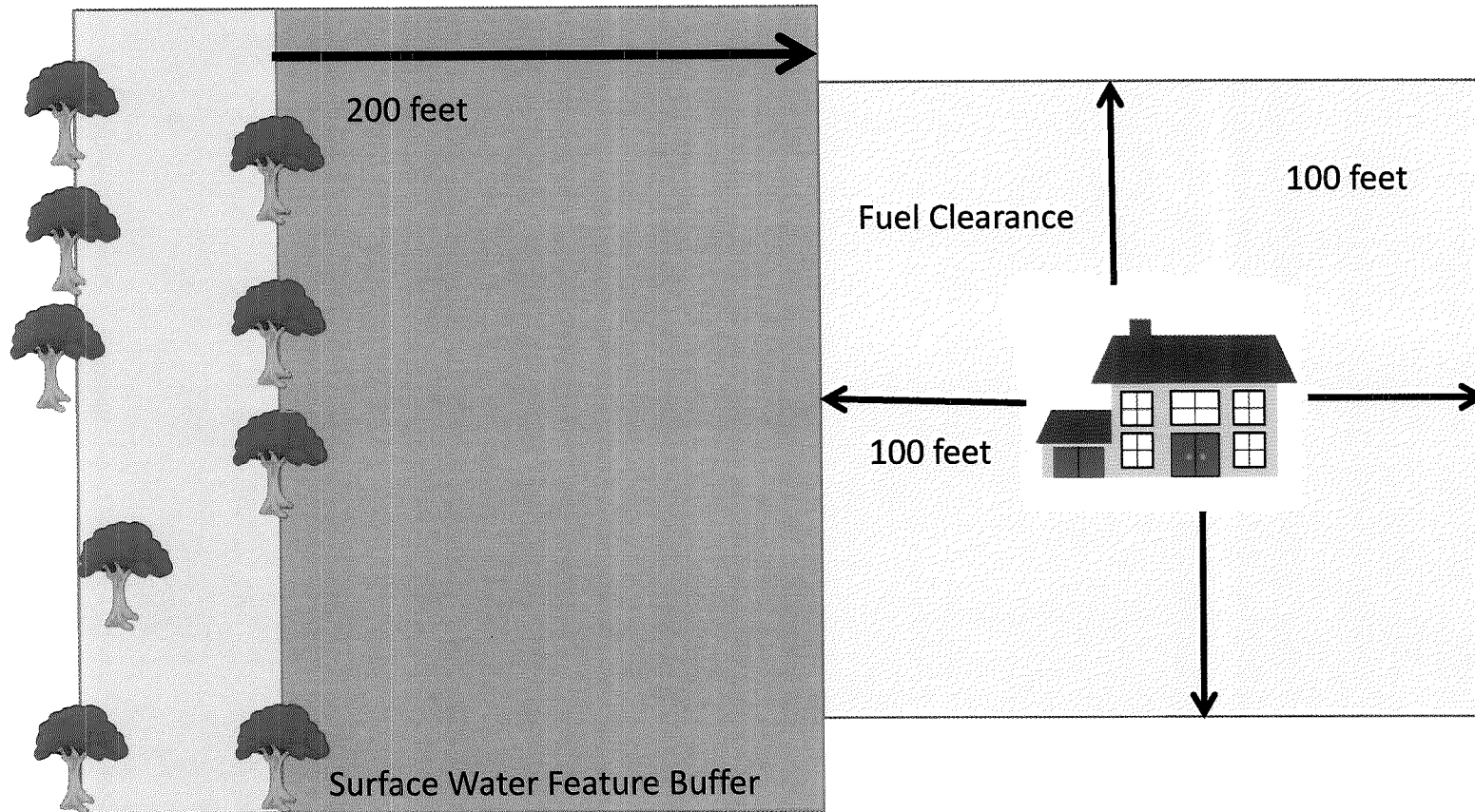
RHL Overlay Zone Regulations

Surface Water Features - § 8109 – 4.8.4

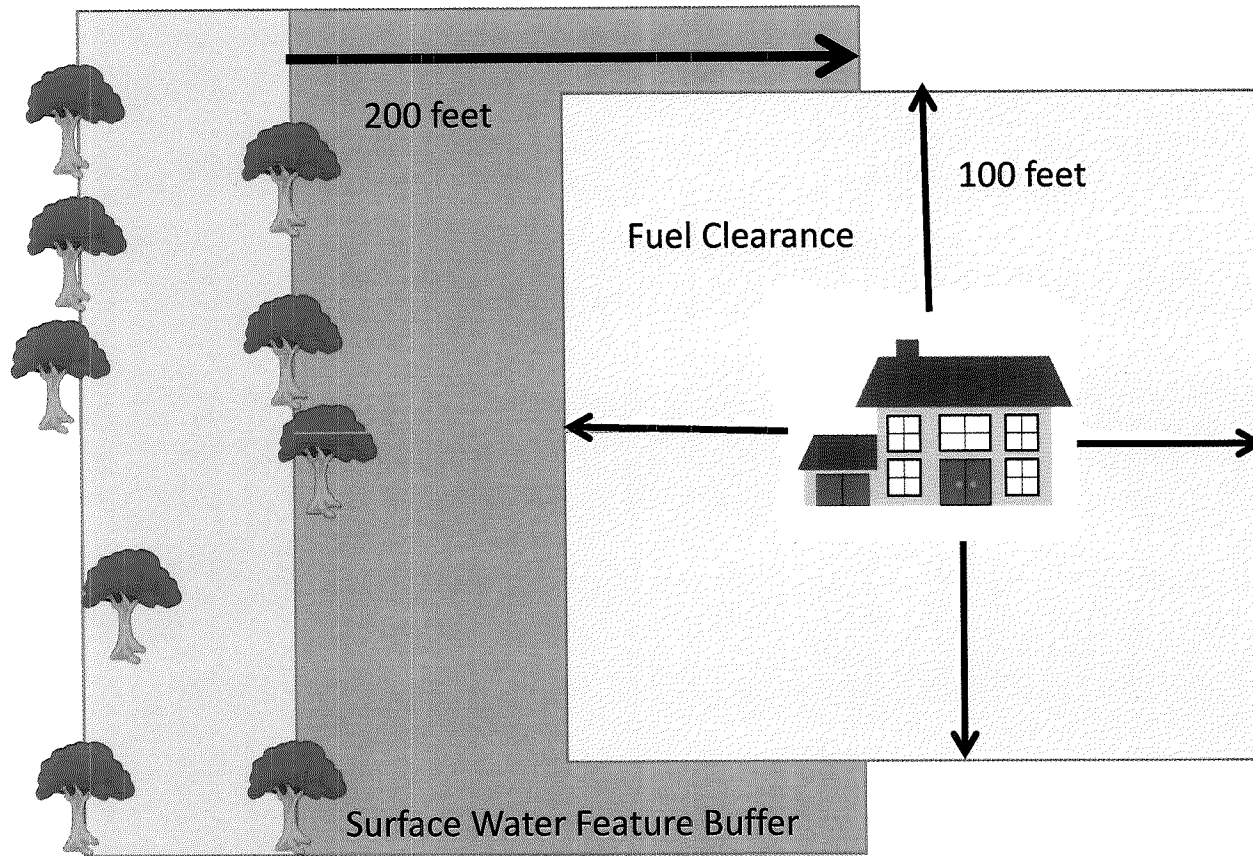
Waters depicted on the *National Wetlands Inventory Dataset*, as amended. Data consists of mapped wetlands and riparian areas. Freshwater ponds, lakes and agricultural water impoundments are excluded from definition. Buffer distances are measured from the farthest extent of both the mapped wetland and riparian areas.

- ❖ Proposed 200-foot buffer on either side of a “mapped surface water feature.”
- ❖ New structures/uses within buffer would require a discretionary permit, including structures/uses that are now Exempt or Ministerial.
- ❖ Vegetation removal within buffer would require a discretionary permit.

A structure with fuel clearance that does NOT encroach within a Surface Water Feature Buffer would require a Ministerial Zoning Clearance



A structure with fuel clearance that DOES encroach within a Surface Water Feature Buffer would require a Discretionary Permit



RHL Overlay Zone Regulations

Surface Water Features

Exemptions:

A Planned Development permit is not required for the following:

Any addition to an existing legally established *structure*, or any new *accessory structure* within a mapped *surface water feature 200-foot buffer area*, provided the addition will not result in any *vegetation* modification within the buffer area that would require additional fuel modification required by the Ventura County Fire Protection District (VCFPD).

RHL Overlay Zone Regulations

Surface Water Features

Exemptions Continued:

- ❖ Grading or excavation of cumulative area of 500 sq. ft. or smaller, or grading to improve drainage within 50 feet of any existing *structure*, not otherwise regulated by Appendix J of the Ventura County Building Code;
- ❖ Restoration of land and improvements to their prior condition following natural disasters;
- ❖ Construction of any *structure* pursuant to Sec. 8113-6;
- ❖ Planting of crops or orchards that will be commercially sold.
- ❖ Removal of *vegetation* on previously cultivated agricultural land that may have been left uncultivated for up to ten years, or on land classified as “Prime,” or “Statewide Importance”, “Unique,” or “Local Importance,” or “Grazing” by the California Department of Conservation Important Farmlands Inventory associated with 1.) Agricultural crops, 2.) livestock grazing, and 3.) Construction and maintenance of driveways or roads internal to the lot.

RHL Overlay Zone Regulations

Surface Water Features

Exemptions Continued:

- ❖ *Vegetation* removal authorized by a public agency;
- ❖ Vegetation removal on land owned by a conservation organization or on land in which a Conservation Organization or on land in which a Conservation Organization maintains a recorded ownership interest;
- ❖ Removal of *vegetation* that has been intentionally planted as a landscape;
- ❖ *Vegetation* modification required by the Ventura County Fire Protection District (VCFPD) for legally permitted structures
- ❖ *Vegetation* removed by a public agency to protect public health and safety.

RHL Overlay Zone Regulations

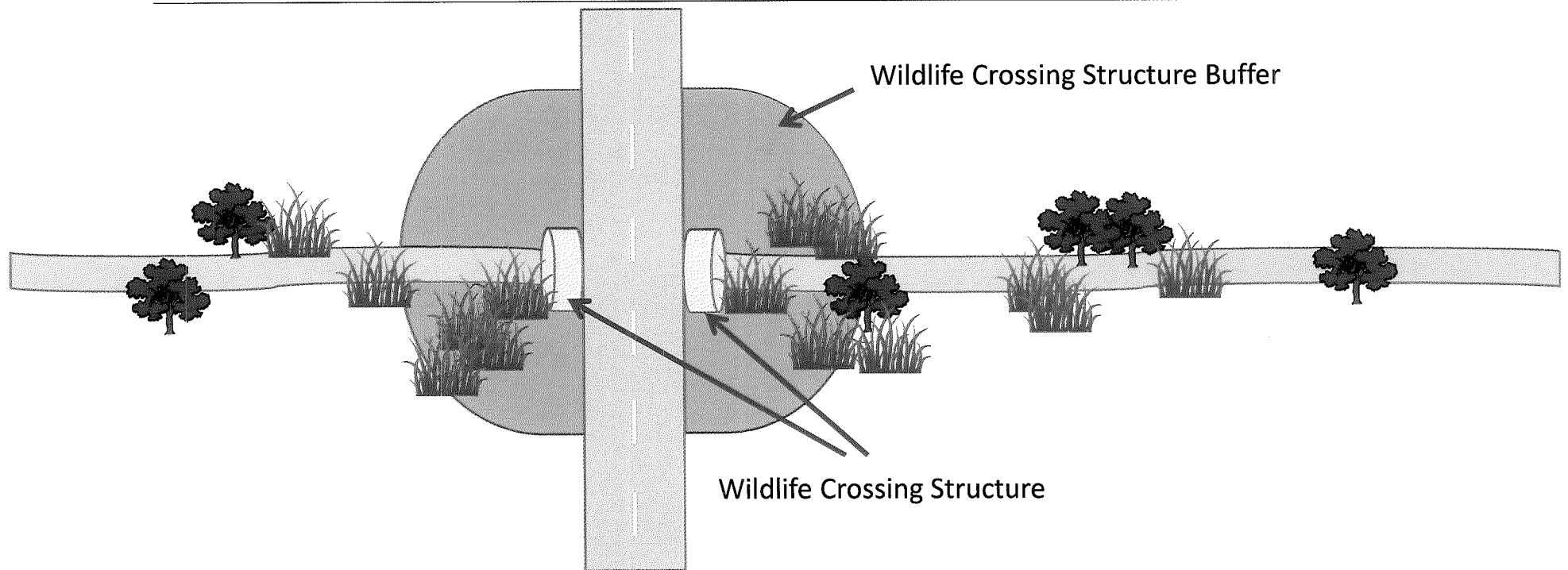
Wildlife Crossing Structures § 8109 – 4.8.5

Wildlife Crossing Structure: Structures that allow animals to cross human-made barriers safely, such as culverts, bridges, and underpasses.

Planning Director-approved Planned Development permit required for vegetation removal or new *structures* on private property outside of the Caltrans or County right-of-way if within the following:

- ❖ 300 feet of the entry and exit of a *HF wildlife crossing structure*; or
- ❖ *100 feet of the entry and exit of a MF wildlife crossing structure.*

Wildlife Crossing Structure Diagram



RHL Overlay Zone Regulations

Wildlife Crossing Structures -continued

Highly Functional and Moderately Functional Wildlife Crossing Structures – Depends on the number of features present that support increased use by wildlife including:

- ❖ Vegetation that provides cover located near entrances
- ❖ The “openness” of a crossing, a function of its height, width, and length
- ❖ Landscape features such as drainages that lead wildlife to a crossing
- ❖ Suitable wildlife habitat is located nearby

RHL Overlay Zone Regulations

Wildlife Crossing Structures

Exemptions:

- ❖ Maintenance required to clean out soils, debris and overgrowth consistent with all regulations and permits;
- ❖ Additions to legally established structures or new accessory structures if no additional vegetation modification is required by the Fire District;
- ❖ Grading or excavation that involves a cumulative area of 500 square feet or smaller, or grading to improve drainage within 50 feet of any existing *structure*, not otherwise regulated by the Ventura County Building Code.

RHL Overlay Zone Regulations

Wildlife Crossing Structures

Exemptions Continued:

- ❖ Restoration of land and improvements to their prior condition following natural disasters;
- ❖ Construction of any *structure* pursuant to Sec. 8113-6; (Destruction)
- ❖ Planting of crops or orchards that will be commercially sold;
- ❖ Removal of *vegetation* on previously cultivated agricultural land that may have been left uncultivated for up to ten years, or on land classified as “Prime,” or “Statewide Importance”, “Unique,” or “Local Importance,” or “Grazing” by the California Department of Conservation Important Farmlands Inventory associated with 1.) Agricultural crops, 2.) livestock grazing, and 3.) Construction and maintenance of driveways or roads internal to the lot.

RHL Overlay Zone Regulations

Wildlife Crossing Structures

Exemptions Continued:

- ❖ *Vegetation* removal authorized by a public agency;
- ❖ Vegetation removal on land owned by a conservation organization or on land in which a Conservation Organization or on land in which a Conservation Organization maintains a recorded ownership interest;
- ❖ Removal of *vegetation* that has been intentionally planted as a landscape;
- ❖ *Vegetation* modification adjacent to existing legally permitted buildings as required by the Ventura County Fire Protection District; and
- ❖ *Vegetation* removed by a public agency as required by, or consistent with regulations to protect public health and safety.

RHL Overlay Zone Regulations

Wildlife Crossing Structures (& Surface Water Features)

Deviations:

- ❖ The Planning Director or designee may approve a deviation from the *vegetation* removal standards.
- ❖ A deviation request for a proposal to remove vegetation shall be granted provided that at least 60 percent of the vegetated area to be removed comprises *invasive plants*.

RHL Overlay Zone Regulations

Invasive Plant Prohibition §8109 – 4.8.6

The intentional planting of *invasive plants* is prohibited throughout the *RHL overlay zone*, except those planted as commercial agricultural crops or grown as commercial nursery stock.

No additional exemptions

RHL Overlay Zone Regulations

Wildlife Impermeable Fencing § 8109-4.8.7

Fencing that prevents various species of wildlife (including amphibians, reptiles, mammals, birds), from freely passing through a fence with little or no interference.

- ❖ Applies to any portion of a new or replacement fence (except gates), which forms an enclosure.
- ❖ *Wildlife impermeable fencing* includes one or more of the following features:
 - Higher than 60 inches above grade, including any wire strands that are placed above a top rail of a fence.
 - Electric *fences* comprised of any material or number of electrified strands.
 - Wrought iron, plastic mesh, woven wire, razor wire, chain link, and any solid wall (e.g., brick, cinderblock) or *fence* (e.g., wood or vinyl).

Applicability

- ❖ On lots zoned Open Space (OS) or Agricultural Exclusive (AE) only
- ❖ In all zones, any *fence* installed or replaced as part of a new discretionary permit or major permit modification shall be reviewed as part of the whole discretionary entitlement to minimize impacts to wildlife movement.

RHL Overlay Zone Regulations

Wildlife Impermeable Fencing - Permits

❖ Ministerial Permit

For lots with no *existing wildlife impermeable fencing*, the cumulative area enclosed by the proposed *fencing* shall not exceed ten percent of the gross lot area; or

For lots with *existing wildlife impermeable fencing* the cumulative area enclosed by the proposed *fencing* shall not exceed ten percent of the gross lot area, excluding the cumulative area already enclosed by *existing wildlife impermeable fencing*.

RHL Overlay Zone Regulations

Wildlife Impermeable Fencing - Permits

❖ Discretionary Permit

For lots with no *existing wildlife impermeable fencing*, the cumulative area enclosed by the proposed fencing is greater than ten percent; or

For lots with *existing wildlife impermeable fencing*, the cumulative area enclosed by the proposed *fencing* is greater than ten percent of the gross lot area excluding the cumulative area already enclosed by existing *wildlife impermeable fencing*.

RHL Overlay Zone Regulations

Wildlife Impermeable Fencing

Exemptions:

- ❖ Any WI fence in a Residential zone
- ❖ Any WI fence installed prior to the effective date of the ordinance amendment
- ❖ Any WI fence necessary to enclose commercially grown agricultural products, defined as any plant product (including food, plant fiber, feed, ornamentals, or forest), that will be commercially sold.
- ❖ Any WI fence that is required by any federal or state law or local regulation
- ❖ Any WI fence within 50 feet from the exterior walls of any dwelling or a principal structure related to agriculture

RHL Overlay Zone Regulations

Wildlife Impermeable Fencing

Exemptions:

- ❖ Any WI fence on lots with an area of 10,000 square feet or less
- ❖ Any WI fence associated with a water well or pump house, no larger than 500 sqft.
- ❖ Any WI fence installed by or for a public agency for the sole purpose of restricting wildlife from entering a road right-of-way or directing wildlife toward road crossing structures.
- ❖ Wildlife impermeable fencing or wall spans that do not form an enclosure.
- ❖ Any wildlife impermeable fencing used for habitat protection/restoration by a conservation organization, or public agency.

RHL Overlay Zone Regulations

Wildlife Impermeable Fencing

Prohibited Fencing:

- ❖ *Wildlife impermeable fencing* on any lot that has no *principal use or structure*.
- ❖ *Wildlife impermeable fencing* around the perimeter of a lot, unless otherwise exempt.

Critical Wildlife Passages Overlay Zone

§8109 – 4.9

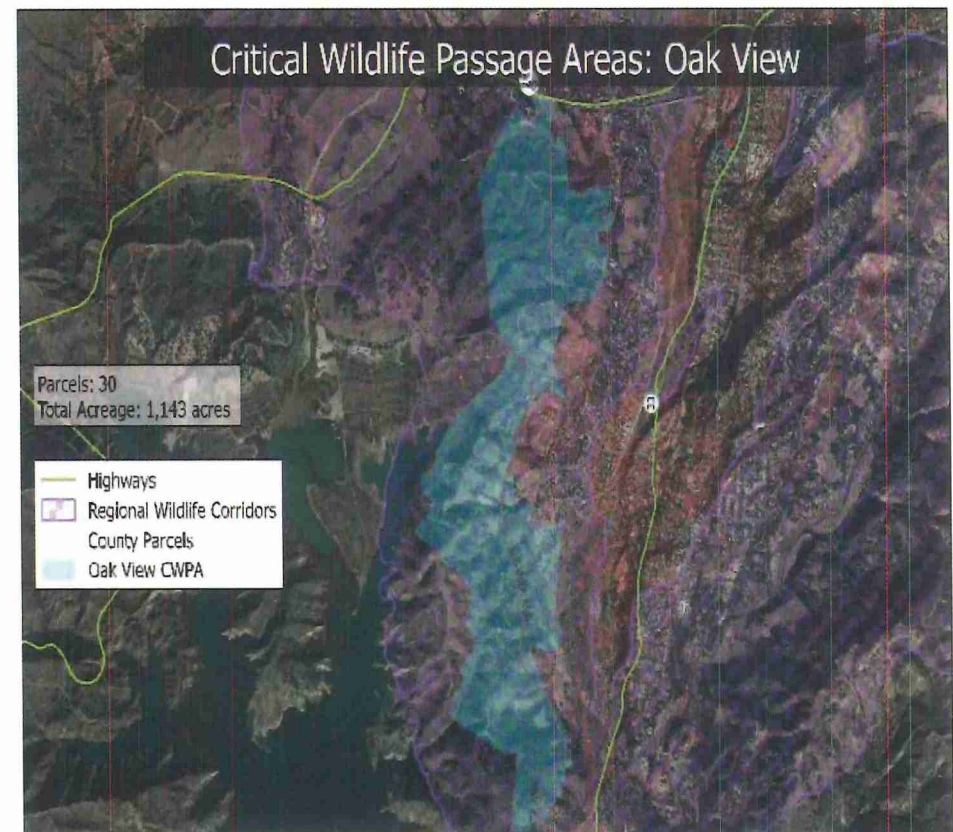
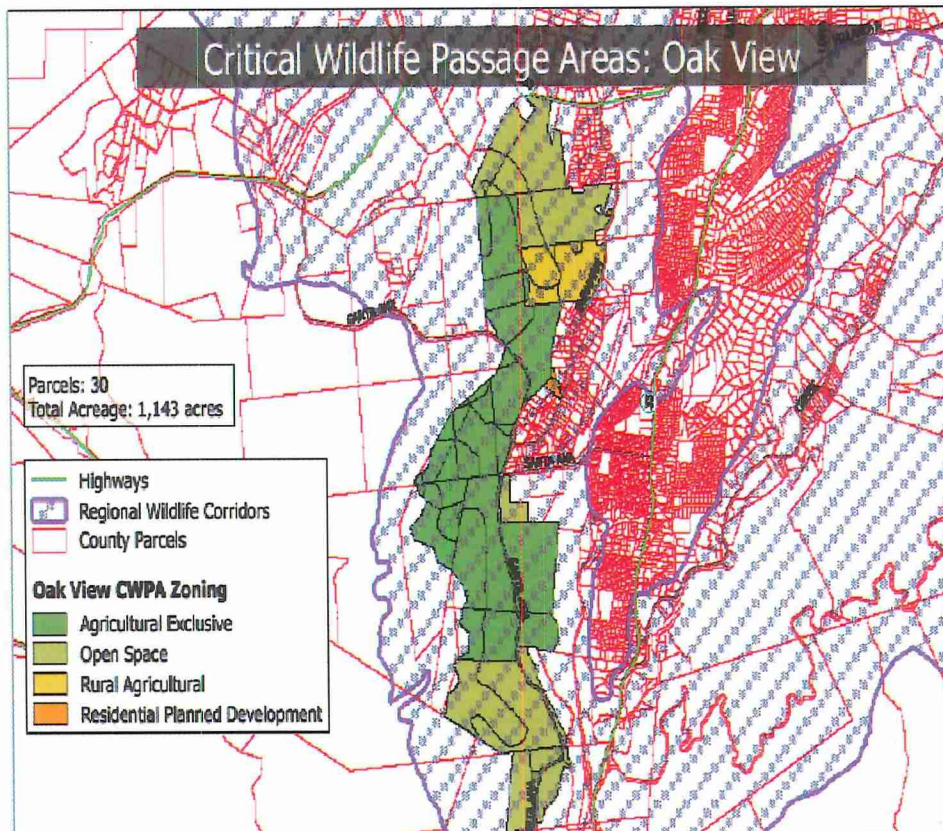
- ❖ Portions of Oak View
- ❖ Tierra Rejada Valley
- ❖ Simi Hills

Critical Wildlife Passage Area Overlay Zone

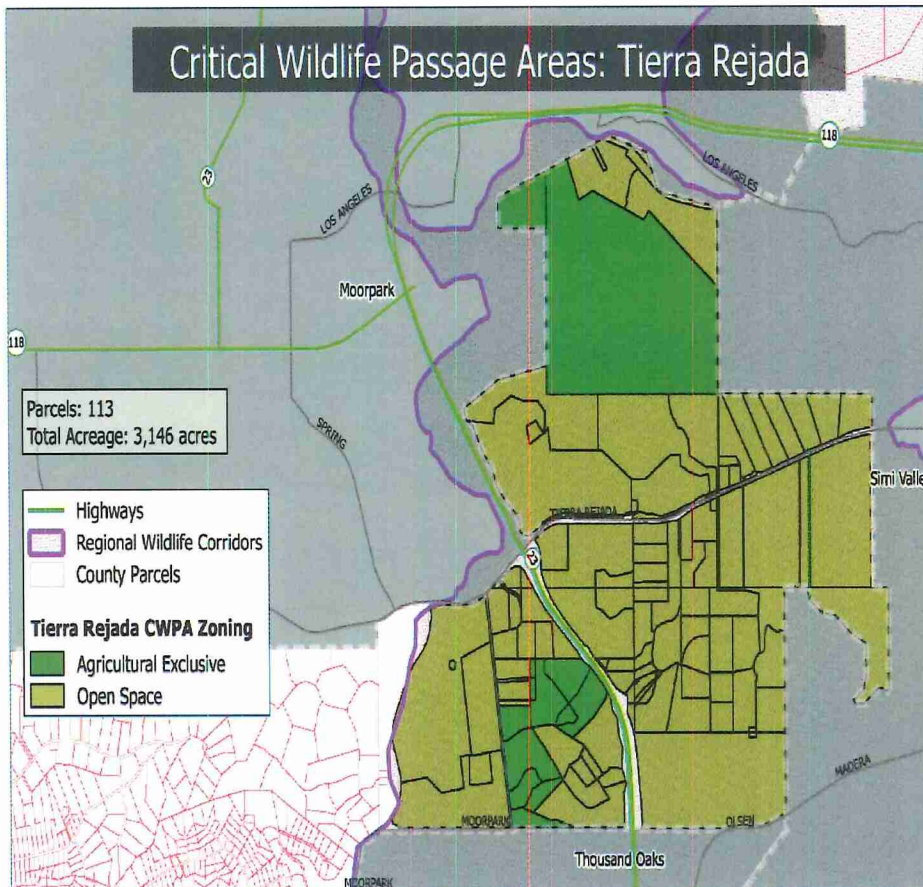
§ 8109-4.9

Areas determined to be particularly critical for wildlife movement due to:

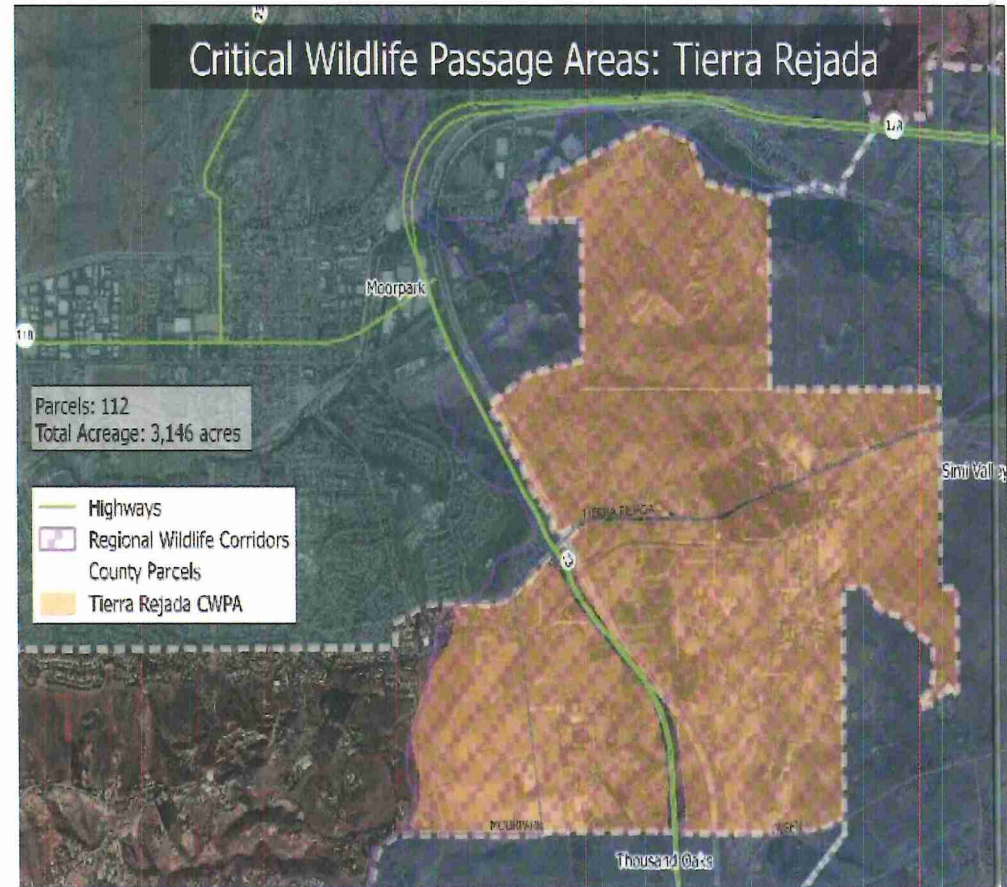
- ❖ Intact, native habitat or higher habitat values;
- ❖ Proximity to water bodies or ridgelines;
- ❖ Proximity of critical roadway crossings;
- ❖ Likelihood of encroachment by future development, and within which wildlife movement and plant dispersal could be easily disturbed by development;
- ❖ Presence of undeveloped lands within a geographic location that connects core habitats at a regional scale.

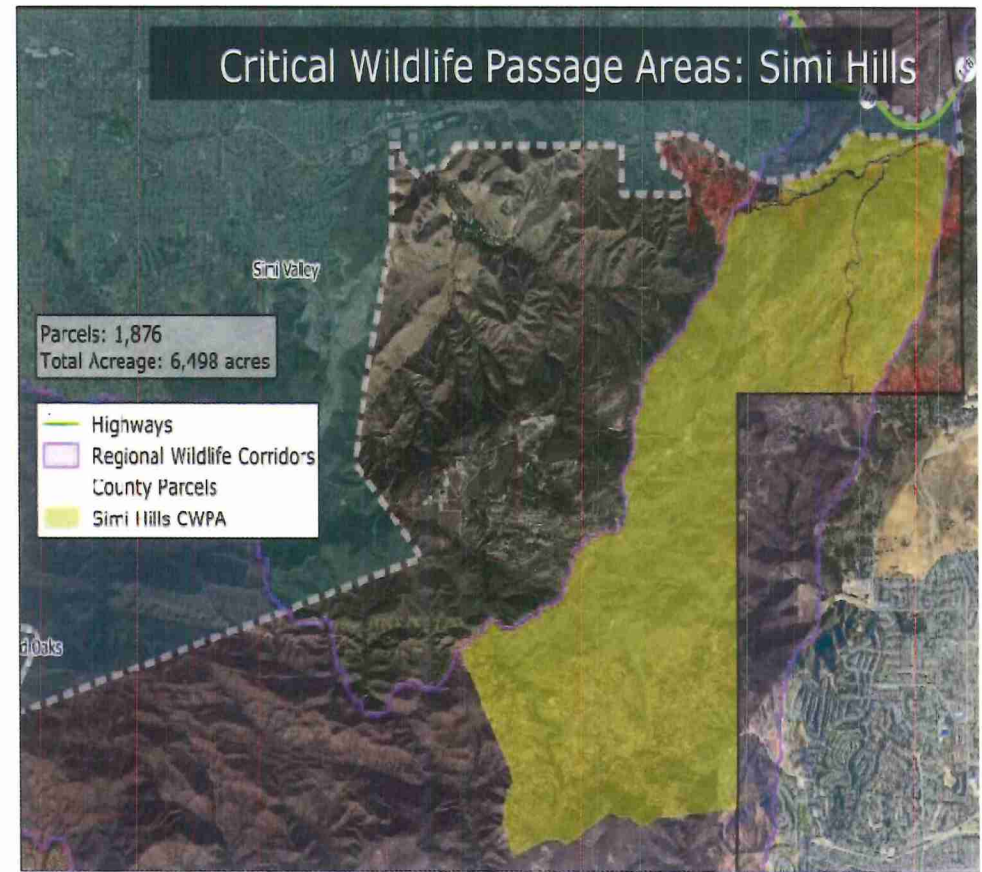
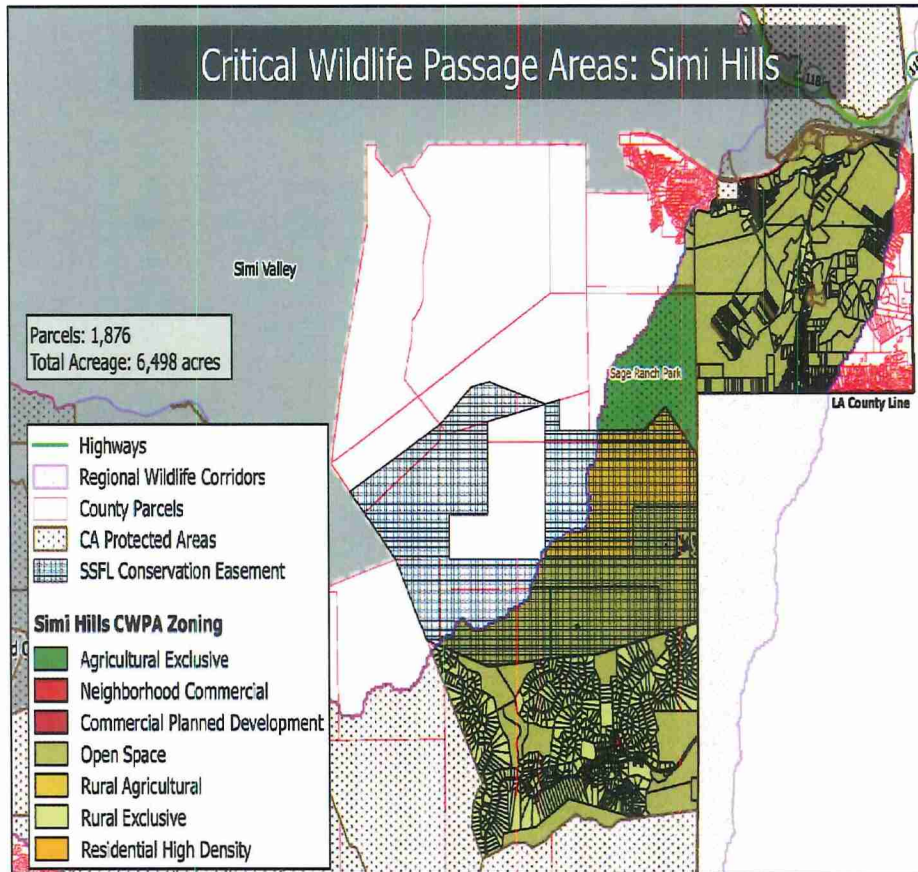


Critical Wildlife Passage Areas: Tierra Rejada



Critical Wildlife Passage Areas: Tierra Rejada



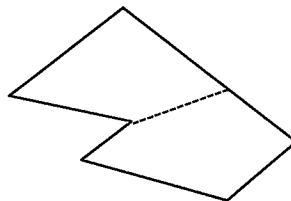
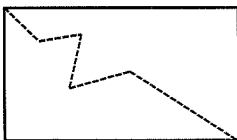
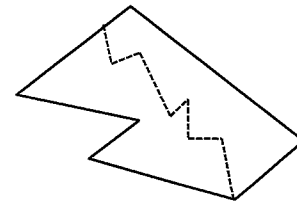
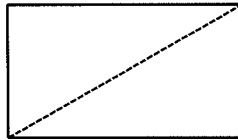
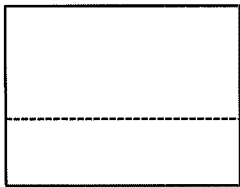


CWPA Overlay Zone Regulations

Compact Development Siting Standard

- ❖ The purpose of the *CWPA overlay zone* is to address habitat fragmentation by siting *structures* in a *compact development* pattern within individual lots, thereby preserving more undeveloped, open areas for native plants and wildlife to move.
- ❖ Any proposed *structure* or use shall be sited exclusively in one of the two contiguous areas created by a line bisecting a single lot into two sections of equal areas (halves).

Examples of Lines Bisecting Lots into Two Sections of Equal Area



CWPA Overlay Zone Regulations

Compact Development Siting Standard

- ❖ If any existing *structure* or use is present within both halves, any new *structure* or use must be sited in the half with the largest relative cumulative area of existing building coverage.
- ❖ Once the location of the bisecting line for a lot is approved by the Planning Division, it shall not be modified and shall be the basis of siting any future *structure* or use pursuant to this section.

CWPA Overlay Zone Regulations

Compact Development - Applicability

Applies in all *critical wildlife passage areas* to any *structure*, use, or *wildlife impermeable fencing*, on lots meeting the following zoning and size criteria:

- ❖ Lots zoned Open Space (OS), Agricultural Exclusive (AE), Commercial (CPD), Industrial (M1, M2, or M3), or Timber Preserve (TP) and larger than one acre; or
- ❖ Any proposed *structure* or use on vacant lots zoned as Residential (RA, RE, RO, R1, R2, RPD, RHD) and larger than one acre; or
- ❖ Any addition to any *existing structure* or modification to any existing use on lots zoned as Residential (RA, RE, RO, R1, R2, RPD, RHD) that are larger than two acres.

CWPA Overlay Zone Regulations

Compact Development - Permits

For a proposed structure or use, the type of permit required (ministerial or discretionary) depends on whether it complies with any of the following:

- ❖ The compact siting standard; or
- ❖ Located within 50 feet of an existing legally established *structure*, use, public road or street, or driveway; or
- ❖ Located within 50 feet of an agricultural access road necessary to support the production of *commercially grown agricultural products*. For purposes of this section, *commercially grown agricultural products* are defined as any plant or animal agricultural product (including food, feed, fiber, ornamentals, or forest), that will be commercially sold, including livestock raised for commercial production.

CWPA Overlay Zone Regulations

Compact Development

Exemptions:

- ❖ Lots where only a portion is within the CWPA overlay zone
- ❖ Any structure or use that is on property zoned Commercial or Industrial
- ❖ Grading or excavation within 50 feet of an existing structure to improve drainage
- ❖ Planting of crops and orchards that will be commercially sold

Proposed Revisions

Ordinance sections proposed for revision since release of public draft dated August 6, 2018. All subsection references below are in Section 8109.

- Ordinance Title and Definitions
- 4.8.1.b (5), (6), (7), (9)
- 4.8.3d
- 4.8.3.1e (4) and g(5)
- 4.8.4 1a and c
- 4.8.5
- 4.8.7
- 4.8.7.1, and 4.8.7 1a
- 4.8.7.2 a(5)
- 4.8.7.3 b(2)
- 4.8.7.4
- 4.8.8
- 4.9.1
- 4.9.6

Tentative Hearing Dates

- ❖ Planning Commission – September 6, 2018
- ❖ Board of Supervisors – October 30, 2018

<https://www.vcrma.org/habitat-connectivity-and-wildlife-movement-corridors>

county of ventura

September 22, 2015

Board of Supervisors
County of Ventura
800 South Victoria Avenue
Ventura, CA 93009

SUBJECT: A Presentation to the Board of Supervisors to Approve a Scope of Work, Preliminary Proposed Budget and Timeline for a Ventura County General Plan Update

RECOMMENDATIONS FOR BOARD OF SUPERVISORS:

1. **RECEIVE & FILE** staff's presentation regarding the General Plan Update (GPU) Work Program, preliminary proposed budget, timeline and Scope of Work;
2. **APPROVE** the recommended GPU Work Program and direct the RMA Planning Division to prepare and issue a Request for Proposals to seek consultant assistance to complete the GPU Scope of Work.

FISCAL/MANDATES IMPACT:

There is no fiscal impact associated with the recommended actions. Should the Board approve the recommended actions, staff will proceed with the preparation and release of a Request for Proposals (RFP) to consultants to provide assistance in the preparation of the General Plan Update (GPU). This work effort can be accommodated within the Resource Management Agency's FY 2015/2016 Adopted Budget. Following completion of the RFP and consultant selection process, staff will return to the Board for authorization to execute a contract for consultant services. At that time, when costs and schedules have been defined, a complete fiscal impact assessment will be presented to your Board.

DISCUSSION:

The essential phases of the GPU have been discussed at length at the Board and Planning Commission meetings held on July 7, 2015 and August 4, 2015. These phases include:

- Phase 1 – Project Initiation
- Phase 2 – Background Research
- Phase 3 – Confirming Assets, Issues, Opportunities and Vision
- Phase 4 – Evaluating Focus Area Alternatives and Policy Options
- Phase 5 – Preparing the Policy Document
- Phase 6 – Environmental Review



Phase 7 – Public Review, Final Documents, and Adoption

During consideration of the GPU scope of work, your Board indicated an interest in pursuing elements and topics that are beyond those mandated by the state. As such, the recommended work program (Exhibit 1) reflects a comprehensive update that includes three optional elements (water, agriculture, and economic development), and inclusion of several contemporary topics (healthy communities, sustainability, and climate change). The GPU also includes a focused visioning process and alternatives analysis and extensive public engagement. The specific topics to be addressed in an economic development element would be informed and fully identified during the preparation of the Background Report. However, it is anticipated that analysis of the agricultural industry and other existing agricultural and open space uses, as well as commercial and industrial uses within the existing communities, would be evaluated. Exhibit 2 provides some examples of specific agriculture-related issues that could be addressed in an economic development element.

Your Board also indicated that it did not wish to engage in a comprehensive “visioning” process but to develop a General Plan vision based on well-established policies (e.g., the Guidelines for Orderly Development) and newer policies (e.g., Health in All Policies) that could be affirmed, in part, through a community survey. Also, while your Board directed that no broad land use alternatives be pursued, policy alternatives should be developed and evaluated, and focused land use alternatives, if identified through the GPU process, should also be considered. Said another way, if the data and outreach program concluded that more land is needed to be rezoned to industrial (for example, to accomplish the Goals or Objectives of the General Plan), such a focused land use alternative would very likely require an update to an Area Plan. As this is an “unknown” at this point in the process, no comprehensive Area Plan updates have been included in the recommended GPU scope of work; only the consistency analysis and reformatting and integration of the Area Plans into the General Plan have been included in the recommended scope of work.

In addition to the basic GPU preparation phases outlined above, your Board requested three related tasks be undertaken concurrently with the GPU effort – those tasks include an updated Housing Element, Concurrent Zoning Code Update (to include parcels which are inconsistent with the General Plan), and comprehensively addressing the protection of wildlife corridors. These three areas are touched on individually below.

The Housing Element is a mandated program that is on a state-established schedule. Ventura County's Housing Element is due in 2021. One of the requirements for completion of the Housing Element is timely receipt of the new Regional Housing Needs Assessment (RHNA) numbers. If the release of RHNA calculations from the State Department of Housing and Community Development (HCD) coincides with the preparation of the GPU, this work could be done concurrently and be completed in advance of the 2021 deadline. However, the certification process by HCD may occur after the GPU update, and staff has no control over this timing.

The concurrent Zoning Code Update is a program that would accomplish two objectives. First, the long standing issue of existing parcels which are inconsistent with the overlying General Plan land use designation would be addressed by processing necessary zoning map (and minor text) amendments. Second, in a concurrent process, the Zoning Ordinance¹ maps and text would be updated to ensure consistency with the General Plan Update. When a jurisdiction adopts a new General Plan, the agency is given a reasonable amount of time (one to two years to update their Zoning Ordinances to ensure consistency with the General Plan). The funds for this program would have to be expended regardless of timing (i.e. concurrently with the GPU or within two years of adoption), but the Planning Division staff and our consultants believe that an economy of scale can be achieved in concurrent processing. This will lead to a core group in the Planning Division working with the consultant preparing the Program Environmental Impact Report (PEIR) and the GPU team to ensure consistency with General Plan, Area Plans, and our ordinances.

Although the Wildlife Corridor Connectivity Protection program will likely include amendments to the General Plan, a significant amount of the work needed to complete this program will require amendments to the Non-Coastal Zoning Ordinance (and possibly to the Coastal Zoning Ordinance). Similar to the Zoning Code update described above, Planning Division staff and the consultant believe there would be a savings/efficiency if this program were also processed concurrently with the update to the General Plan

As your Board recommended these programs be included in the GPU process, the revised scope of work and preliminary budget (Exhibit 1) has been updated to reflect these tasks.

The estimated cost for the General Plan Update with a scope of work including the items discussed above is approximately \$4,476,500. It is anticipated that this GPU scope of work could be completed within 5 years with the summer of 2020 being the target date.

At your August 4, 2015 meeting, your Board directed staff and the consultant to develop an alternative scope of work that could be completed within a 3 to 3 ½ year time-frame. In response, County staff and our consultants spent considerable time reviewing the recommended scope and— based on the consultant's experience preparing County General Plan updates— identified a number of items within the recommended scope of work that would have to be eliminated to stay on schedule.

When applying a truncated timeline to the recommended scope of work, consideration was given both to the extent of the work needed to complete the task and also to the potential for controversy and comment. In short, an abbreviated time-frame is only feasible if there are limited issues requiring prolonged debate or discussion. Taking this into account, the following are the changes to the recommended scope of work that would be required to meet a 3 to 3 ½ year schedule:

¹ Non-Coastal and Coastal Zoning Ordinances.

1. The Water Element would necessarily be abbreviated as the truncated timeline is not sufficient to cover an issue that is as controversial and complex as water supply/demand in a meaningful way. The timing of a 3 ½ year schedule also does not coincide with the work efforts of the Public Works Department to develop the newly required groundwater sustainability plans. As your Board is aware, on September 16, 2014, Governor Brown signed into law a three-bill legislative package, known as the Sustainable Groundwater Management Act of 2014 (SGMA). The SGMA provides a framework for sustainable management of groundwater supplies by local authorities, with a limited role for state intervention only if necessary to protect the resource. While the precise timing of those efforts is unknown at this point, RMA staff met with staff from PWA and learned that current plans are for the initial data gathering to be completed in the first half of 2017, prior to the deadline for the formation of the required groundwater sustainability agencies. This timeline would not work in a 3 year scenario as the PEIR would necessarily need to be well under way and thus the information gathered in 2017 would not be included in the background report. Based on the experience of staff and the consultant, policy and program level development on water or other topical issues, without detailed and accurate background information results in more generalized and less meaningful policies. Solid policy is based on solid data. The analysis of information to be collected during the planning process will provide your Board with knowledge on trends, existing conditions, and projections that are critical elements when formulating policy.
2. Development of focused land use alternatives, and associated Area Plan updates, if any, cannot be accommodated within the shortened scheduled and would be removed. This means that the alternatives evaluation in the three-year work program would be limited to addressing key policy issues identified through County staff and consultant research, outreach efforts to community members and stakeholders, and meetings with the Planning Commission and your Board to identify preferences for future policies.
3. The Wildlife Corridor Connectivity Protection program could not be accomplished in a shortened review period, as the project previously generated substantial debate and comment. Assuming a similar or greater amount of discussion would be required to formally include it in the General Plan and Zoning Ordinance, this task would necessarily be eliminated to make the abbreviated time-frame achievable. Nonetheless, it would be possible to assign this program to staff not working on the GPU, who could develop new regulations at the ordinance level. Pursuant to the existing General Plan Policies on this topic, the application of any new ordinance level regulations would only apply to discretionary entitlements (i.e., Conditional Use Permits, Subdivisions, etc.) and not to ministerial permits.
4. The Housing Element could not be completed within the abbreviated time-frame, as the timing of the release of the RHNA numbers from HCD, as well as the

allocation of those numbers to various jurisdictions within the region, would not coincide with the preparation of the GPU.

5. The level of community outreach would be necessarily reduced. The recommended program includes utilizing Municipal Advisory Councils (MACs) for 21 meetings out in the community during the preparation of the GPU. The shortened schedule reduces this to 9 meetings.
6. Refining and incorporating the Area Plans into the General Plan, as outlined in the recommended work program, would require sufficient time to modify the plans for consistency with the updated General Plan, streamline them to reduce redundancy, and restructure and integrate them into the General Plan. Because the Area Plans address specific areas of the county, the recommended work program would also include outreach to residents within areas covered by the Area Plans to assure the community that the Plans are not being unnecessarily revised. Under the three-year work program, there wouldn't be sufficient time to properly refine and integrate the Area Plans. Area Plans would only be updated to ensure consistency with the updated countywide General Plan. Area Plans would not be refined to eliminate redundancy with countywide policies and would not be restructured and integrated into the General Plan. The County's overall General Plan framework of a stand-alone countywide General Plan and separate Area Plans would remain unchanged. The Area Plans would also not be incorporated into the Web-based General Plan.

In addition to the above items that would be removed from the GPU scope of work, there is an additional issue that may make the 3 to 3 ½ year schedule extremely difficult to achieve. Recently, RMA Staff met with the staff of the Ventura County Transportation Commission (VCTC) and were informed that the current VCTC schedule for the preparation of the Ventura County traffic model shows the model being completed in 12 to 18 months. This poses a significant challenge because the GPU relies on the traffic model not only for the traffic, noise and air quality impact analyses required for the Program Environmental Impact Report (PEIR) but also the development of the circulation element and other policies. While the VCTC schedule, if maintained, should mean the model is available for the PEIR work, there would be little or no time for the traffic model results to be used to inform policy development and review. It may be possible that an extra expenditure of funds could advance the traffic model development and associated analyses. However, the amount of those costs, and the feasibility of doing so, would not be known until consultant proposals for both the County's GPU and VCTC's traffic model development are received.

The estimated cost for the General Plan Update with a scope of work taking into account the items discussed above is approximately \$3,565,260. It is anticipated that this GPU scope of work could be completed in 3 to 3 ½ years.

Considering the information outlined above, our consultants and staff recommend that your Board proceed with the scope of work and budget outlined in Exhibit 1, which is a comprehensive General Plan Update that includes three optional elements (water, agriculture, and economic development), and inclusion of several contemporary topics (healthy communities, sustainability, and climate change). This will also include the concurrent processing of the Housing Element, Zoning Ordinances and the Wildlife Corridor Connectivity Protection Program as discussed above.

An important factor in reaching this recommendation is that a shortened timeline to process a GPU necessarily means that staff would have to rely more heavily on outside consultants to meet the timeline. That would result in much of the expertise gained during the development of the plan leaving with the consulting firm and not being retained by staff during the implementation stage. The Governor's Office of Planning and Research (OPR), which is the agency who authored the General Plan Guidelines, recognized this as problematic in General Plan updates statewide. Specifically, the OPR General Plan Guidelines state:

Planning agency staff should be involved in the general plan process as much as time and budget considerations allow. Plans that are prepared entirely by consultants may be more difficult to implement. Having planning agency staff involved in the general plan provides a sense of ownership in the plan, creates familiarity with the details of the plan, which make implementation easier, and may build the capacity of the planning agency. When consultants and planning agency staff are both involved in a general plan process, there may be a tendency to have agency staff involved more with the background data and less with analysis and policy alternatives. This is understandable, given that it is often more cost effective to have staff compile background information. However, it is desirable to have staff directly involved with analysis and policy recommendations for the reasons discussed above.

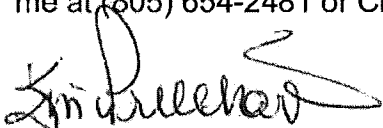
In conclusion, as outlined by our consultant in Exhibit 1, a 3 year work program would provide limited flexibility to address potential, unknown issues that may arise during the Update process. It would assume that:

- there are few or no major controversies as part of the General Plan Update that require additional analysis or public outreach;
- the PEIR is only circulated once;
- the Commission and Board do not need additional meetings to discuss issues or make decisions beyond those identified in the work program; and,
- County staff has sufficient time and resources available to dedicate to the Update project.

If additional analyses, meetings, or staff resources are needed, the schedule would likely extend beyond three years and the cost of the Update would likely increase.

Regardless of the scope adopted by the Board, the first step in the process would be the preparation of a Request for Proposals (RFP), the retention of consultants, and the assignment of appropriate staff within the Long Range Planning Section of the Planning Division. Therefore, it is recommended that your Board direct staff to prepare and issue an RFP and return to the Board at a later date with a recommended consultant contract. Once the consultant and staffing resources are in place, the comprehensive multi-year work effort of the GPU process would commence. With Board approval of a scope of work at your meeting today, staff anticipates the project would commence at the start of the next calendar year.

This Board item was reviewed by County Counsel, the Auditor Controller's Office, and the County Executive Office. If you have any questions regarding this matter, please contact me at (805) 654-2481 or Chris Stephens at (805) 654-2661.



Kim L. Prillhart, Director
Ventura County Planning Division

EXHIBITS:

Exhibit 1: General Plan Updated Scope of Work

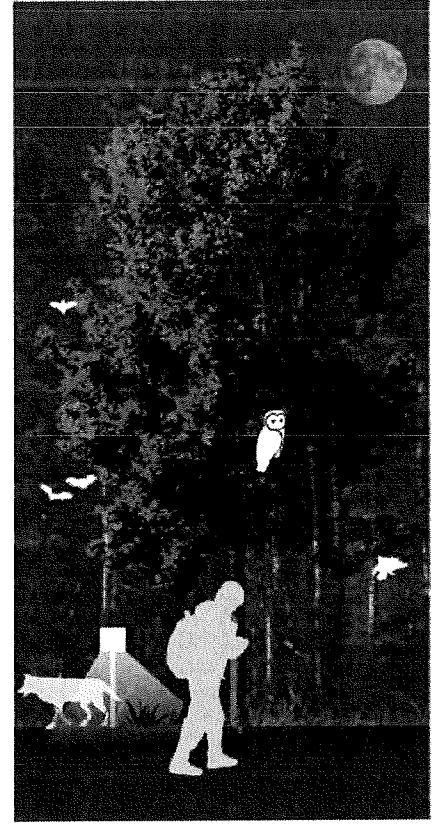
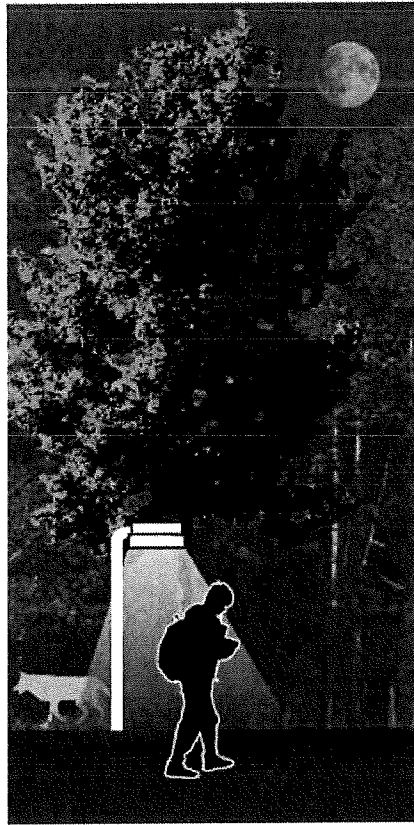
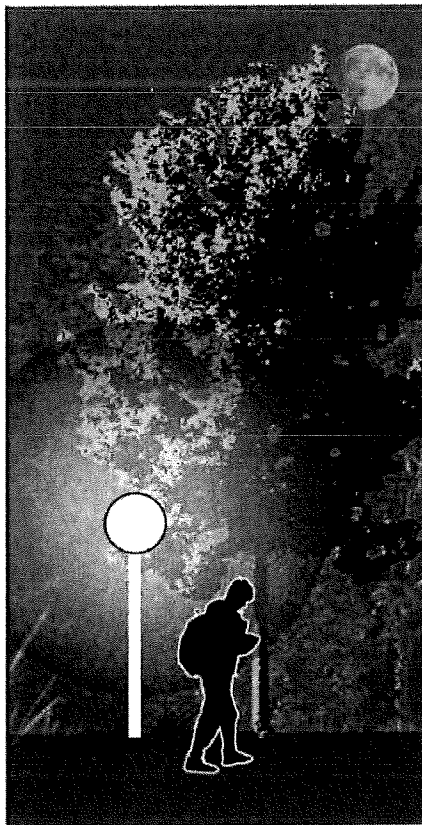
Exhibit 2: Agriculture-focused Economic Development Topics



Artificial Night Lighting and Protected Lands

Ecological Effects and Management Approaches

Natural Resource Report NPS/NRSS/NSNS/NRR—2016/1213



THE
URBAN
WILDLANDS
GROUP



USC School
of Architecture

USC Dornsife

Dana and David Dornsife
College of Letters, Arts and Sciences

ON THE COVER

Example of controlling light direction to reduce environmental consequences

Illustration by Leigha DelBusso

Artificial Night Lighting and Protected Lands

Ecological Effects and Management Approaches

Natural Resource Report NPS/NRSS/NSNS/NRR—2016/1213

Travis Longcore^{1,2,3} and Catherine Rich¹ with illustrations by Leigha DelBusso²

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May 2016

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/nrpm/>). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

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Two natural forms of light at night — from the moon and bioluminescent plankton — contrast with coastal urban lighting in New Jersey, United States. Artificial lighting dramatically changes the intensity and spectrum of light available at night and homogenizes the nocturnal visual environment over space and time. Photograph by Flickr user catalano82 is reproduced with permission.

Executive Summary

Artificial night lighting represents a growing challenge for managers of parks and protected lands. The disruption of natural patterns of light and dark, which have been more or less reliable for millions of years, has a range of adverse consequences for wildlife across taxonomic groups and landscape types. This document reviews effects of artificial night lighting by habitat type and discusses the approaches available to land managers to mitigate and avoid certain adverse effects of artificial night lighting.

Coastal dunes, beaches, and shorelines are a transition zone between terrestrial and aquatic habitats. They often contain gradients of lighting influence from developed shorelines to darker lakes and oceans. Sea turtles are prominent victims of these disrupted lighting regimes. The foraging decisions of many other species are influenced by lighting conditions, embodying tradeoffs between predation risk and dietary needs.

Deserts and scrublands are open habitats with few barriers to light transmission. They are also often hot in the day, with large proportions of nocturnal and crepuscular species avoiding thermal stress. Many nocturnal desert species prefer low illumination levels and have good visual performance under the faint light of the darkest nights.

Wetlands and rivers are often dark spots surrounded by lights, especially when close to human settlement. Movement of species into and out of wetlands and streams is influenced by lights, as is the movement of animals, such as fishes or aquatic invertebrates, up and down rivers and streams. Downwelling light mediates most predator-prey interactions in the water column. Changing light levels cause predators and prey to change depth. Small prey species are influenced by the phase of the moon, and lighting can degrade conditions favorable to successful foraging. Emerging research demonstrates that lighting influences the developmental rates of wetland organisms such as amphibians.

Islands, oceans, and reefs are increasingly influenced by lights from onshore sources, hydrocarbon extraction platforms, fishing vessels, and all manner of ships. Downwelling light is also a dominant factor in structuring ecosystem processes in marine water columns, and many organisms are sensitive to extremely small changes in light levels. Extensive vertical migrations are driven by changes in surface illumination. Changes in surface lighting can have effects hundreds of meters below the surface. Lighting will alter reproduction and predator-prey interactions, and can attract organisms across wide areas.

Grasslands are also open habitats with few barriers to block lights. Research shows influence of lighting on nesting behavior of birds, distribution of predators, and signaling by bioluminescent organisms such as fireflies.

Deciduous and evergreen forests can block light and reduce its influence, but also contain communities of forest floor species adapted to lighting levels much dimmer than in exposed habitats. Therefore even low levels of light can influence foraging times or timing of reproductive activity.

Alpine and tundra habitats are well represented in protected lands. Many species have annual rhythms designed to avoid the harsh winter that are potentially disrupted by lighting cues. In alpine habitats, the slope of the land potentially exposes habitats to direct glare from downslope sources in addition to light reflected in the atmosphere.

Finally, *urban environments* have many artificial light sources, but still can support significant biodiversity in the form of both resident and migratory species. Migratory birds are attracted to lighted structures at night and collide with windows during the day. Some bat species are attracted to insects found under city lights, while others avoid them.

Mitigation of adverse effects of anthropogenic light in these different habitats is guided in five ways:

1. **Need.** Creative solutions are often available to avoid use of lights where they are not absolutely necessary. Especially in natural areas, managers should exercise discretion in limiting the lighting infrastructure.
2. **Spectrum.** Although no color of light is benign in all situations, managers should avoid lights that have ultraviolet or blue light (shorter wavelengths) and in general use lights with red and yellow hues.
3. **Intensity.** Reducing the intensity of lights can often improve visibility for humans by reducing the contrast between light and shadow, allowing people to see a larger area than they might otherwise be able to discern. Guidelines for lighting intensity from the lighting industry should not be followed when trying to reduce impacts to wildlife, because they are usually higher than necessary for human vision and do not take into account impacts to wildlife.
4. **Direction.** Lights should be shielded such that they only cast light where it is needed, and never be directed upwards.
5. **Duration.** Timers and motion detectors can reduce the time a light is on and may therefore reduce impacts. Curfew hours for lights can also enhance visitor experience.

In this report, many lighting situations are considered, including communication towers, night hiking and mountain biking, campsite lighting, off-road vehicles, monuments, light-assisted fishing, security lighting, bridges, roadway lighting, energy production installations, indoor lighting, lighthouses, and billboards. With careful planning and collaboration, usually with nearby jurisdictions, managers of parks and other protected lands can be leaders in the control of light pollution and increase enjoyment of natural lands from inner city parks to wilderness areas.

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Introduction

Americans have long recognized that parks and protected lands can provide opportunities to see and enjoy the solitude of unspoiled nature, where the natural rhythms of life are allowed to flourish with minimal influence from humans. Managers of parks and protected lands balance the need to provide visitor facilities with the impacts of such infrastructure on the environment. Although night lighting may be a requirement for visitors in some circumstances, scientific research has documented a range of adverse consequences of night lighting on ecosystems and wildlife. The effects of lighting on species and ecosystems can be reduced, and in some instances avoided altogether. This report provides examples of assessing the impacts of night lighting on wildlife, and presents options to retrofit and design lighting that minimize impacts to wildlife and the nocturnal environment.

Extensive outdoor (and indoor) electric lighting is a recent phenomenon. Thomas Edison commercialized the electric light bulb in the late 1880s, and outdoor use was largely limited to cities until well into the 1900s. Electric lights were introduced in city centers as replacements for gas lamps in the late 1880s, with lethal effects on wildlife. Nearly 1,000 migratory birds were killed in collisions after being attracted to an electric light tower in Decatur, Illinois in 1886 (Gastman 1886). Significant outdoor lighting spread with the rural electrification programs of the 1930s and 1940s. More recently, other significant sources of outdoor lighting have spread across large swaths of the globe, primarily through illumination of human settlements and associated transportation infrastructure. Other sources of artificial night lighting have proliferated as well. Lighting associated with oil and gas development illuminates large terrestrial and offshore regions. Similarly, light-assisted fishing operations illuminate oceans in many regions and oceangoing freighters and passenger ships introduce mobile light sources along oceanic routes. Together, these and other light sources introduce novel lighting conditions that have no historical precedent in natural ecosystems. Natural patterns of darkness are lost or endangered globally (Bennie et al. 2015, Duffy et al. 2015, Marcantonio et al. 2015).

This document is divided into two sections. The first section reviews the effects of artificial night lighting on major habitat types. No single solution can mitigate all adverse effects of artificial night lighting. We therefore attempt to generalize the concerns that typify each biome. The second section provides recommendations for management approaches to minimize impacts from lighting. We address the characteristics of lights in terms of need, spectrum, intensity, direction, and duration, with reference to biomes in which each method of control would be applicable. This discussion addresses common lighting applications — roadways, parking, and walkways — as well as specialized situations like night hiking and mountain biking, vanity lighting, communication towers, and light-assisted fishing.

Effects of Artificial Night Lighting on Natural Ecosystems

Natural patterns of light and dark

In the natural world, sources of light are either very predictable or notably ephemeral. The dominant and structuring source of light is the sun, through daylight and the reflected light of moonlight.

Patterns and intensity of sunlight and moonlight vary with geographic location, weather, and time, but they have certain predictable characteristics. For example, the daily, monthly, and seasonal patterns of moonlight and sunlight incident upon the Earth's atmosphere are only rarely interrupted (e.g., by a solar eclipse). Once the sun has set, the brightest possible constant light source is a full moon until the sun rises again (**Figure 1**). The length of the night varies by season and latitude and these patterns are, in the timescale of biological activity, fixed. Weather influences illumination during the day, and does not, with the exception of lightning, increase nocturnal illumination. Fires, lightning, bioluminescence, starlight, airglow, and zodiacal light contribute to nighttime illumination under natural conditions, and these transient sources are brief, rare, or dim in comparison with sunlight and moonlight.

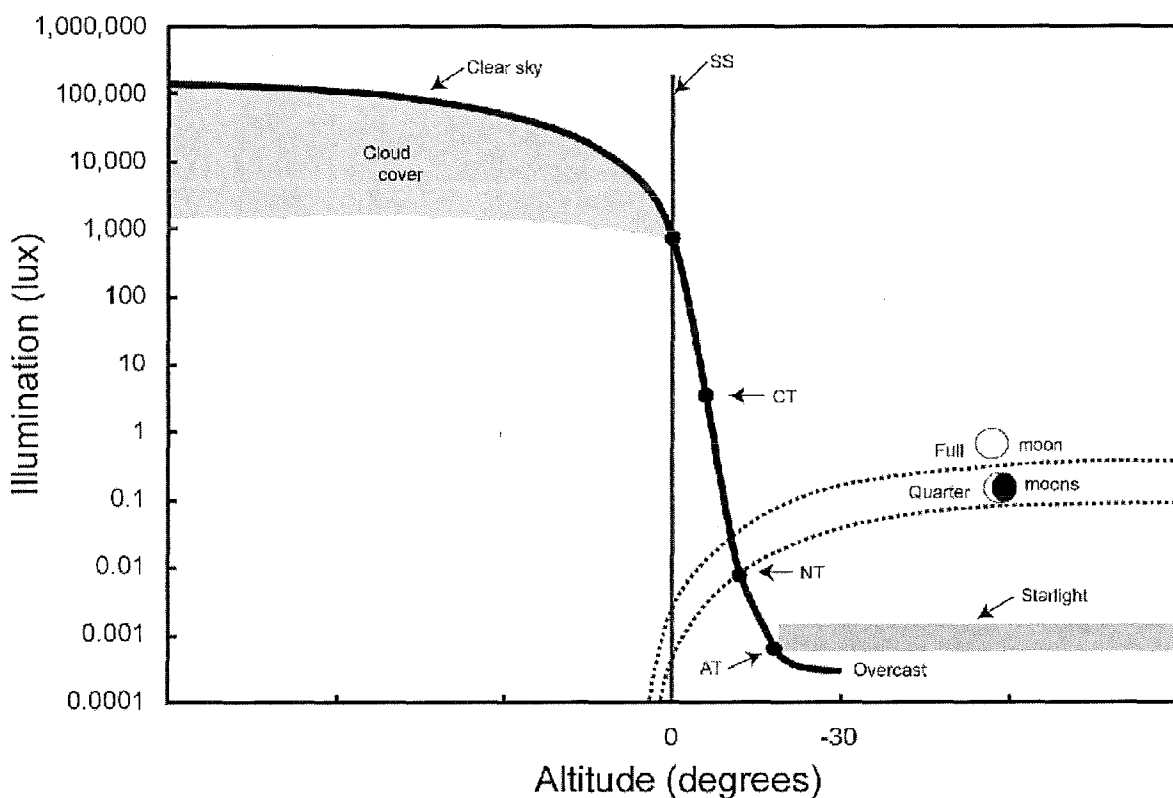


Figure 1. Natural horizontal illumination during the day, sunset, and at night (Beier 2006). Horizontal illumination on the y-axis; x-axis shows altitude above the horizon for the sun and moon. SS = sunset, CT = civil twilight, NT = nautical twilight, AT = astronomical twilight. Modified with permission from Beier (2006).

Light falling on a surface is often measured in lux, a unit of illuminance that sums electromagnetic energy after filtering in accordance with the daytime (photopic) sensitivity of the human eye. Light emitted from a source is often measured in lumens, a unit of luminance that also accounts for the photopic spectral sensitivity of the human eye. Measurements of lux and lumens place more weight on wavelengths to which the human eye responds most strongly, and less on those wavelengths to which the human eye is less sensitive. Similar measurements can be customized for the optic spectral

sensitivities of different species by re-weighting the calculations to emphasize different wavelengths of light (Gal et al. 1999 and **Figure 2**).

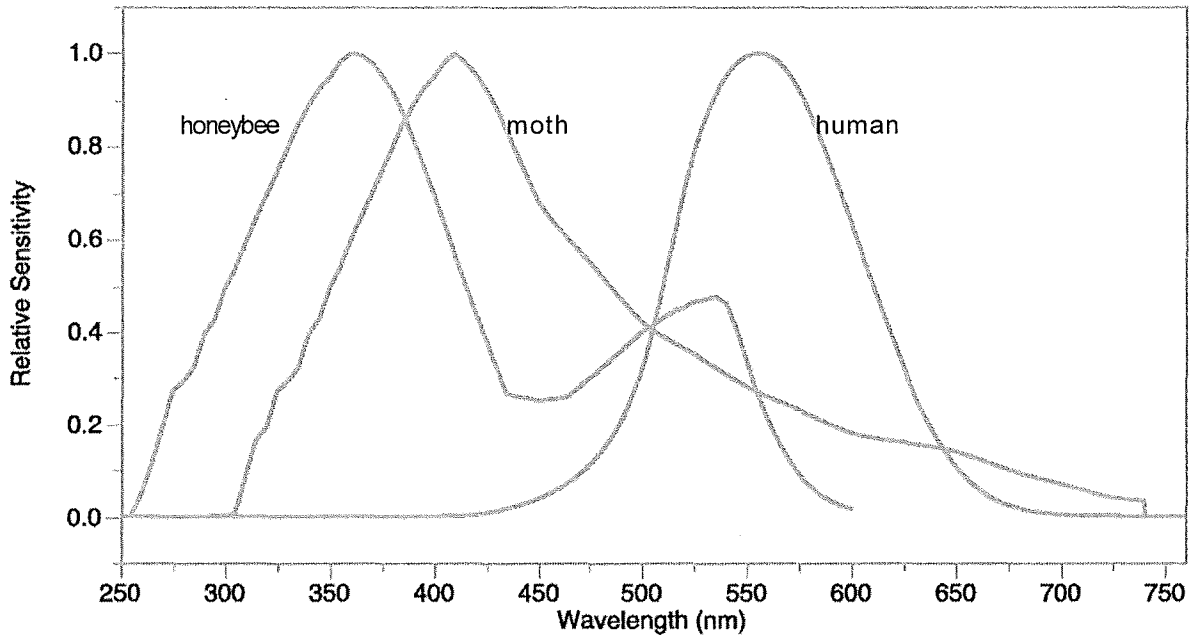


Figure 2. Relative sensitivity to light across the visual spectrum for honeybees (Menzel and Greggers 1985), moths (Cleve 1964), and human photopic vision (CIE 1932).

Outdoor illumination during the day ranges from 100,000 lux in full sunlight to 1,000 lux on a cloudy day (**Figure 1**). Dusk and dawn are transitions into and out of much darker conditions. These transitions are also characterized by predictable changes in the relative intensities of the wavelengths of light. As dusk falls, blue light increases, especially when the moon is new or not present. With moonlight, this blue pulse is diminished or absent and moonlight itself is red-shifted relative to sunlight (Sweeney et al. 2011). Both airglow and zodiacal light also contain more red light than daylight. Variations in illuminance and color trigger many behavioral and physiological processes (Sweeney et al. 2011, Walmsley et al. 2015). Circadian, circannual, and circalunar rhythms are linked to the predictable changes in the light environment. Light triggers can be at different illuminations depending on the environment. What is extraordinarily dim in one environment may be bright in another. For example, the illumination at which activity takes place on a forest floor is on average dimmer than illumination levels triggering the same activity for similar organisms in open grassland. Illumination that is within the natural range of variation on a beach may be far brighter than anything experienced at night at ground level in a dense forest.

Life evolved with predictable daily, monthly, and seasonal patterns of light and dark, and these patterns underlie the natural rhythms of nearly all living organisms. Artificial night lighting has long been known to affect these patterns. Nocturnal species, which represent the majority of some major taxonomic groups (**Figure 3**), are obviously vulnerable, as are diurnal or crepuscular species whose behavioral niches can be distorted by lighting. Concern about adverse effects of lighting dates to

descriptions of the “destruction” of birds at lighthouses in the late 1800s (Allen 1880) and even the first electric urban lighting (Kumlien 1888). Mortality of hatchling sea turtles at lights was identified as a conservation issue in the 1960s (McFarlane 1963). Verheijen coined the term *photopollution* in 1985 (Verheijen 1985), which was followed by Ken Frank’s classic review of the effects of lighting on moths (Frank 1988), and a series of unpublished reports (Outen 1998), conference proceedings (Schmiedel 2001), and research reports from Europe (De Molenaar et al. 2000, Kolligs 2000). In 2004, we described *ecological light pollution* as “artificial light that alters the natural patterns of light and dark in ecosystems” (Longcore and Rich 2004).

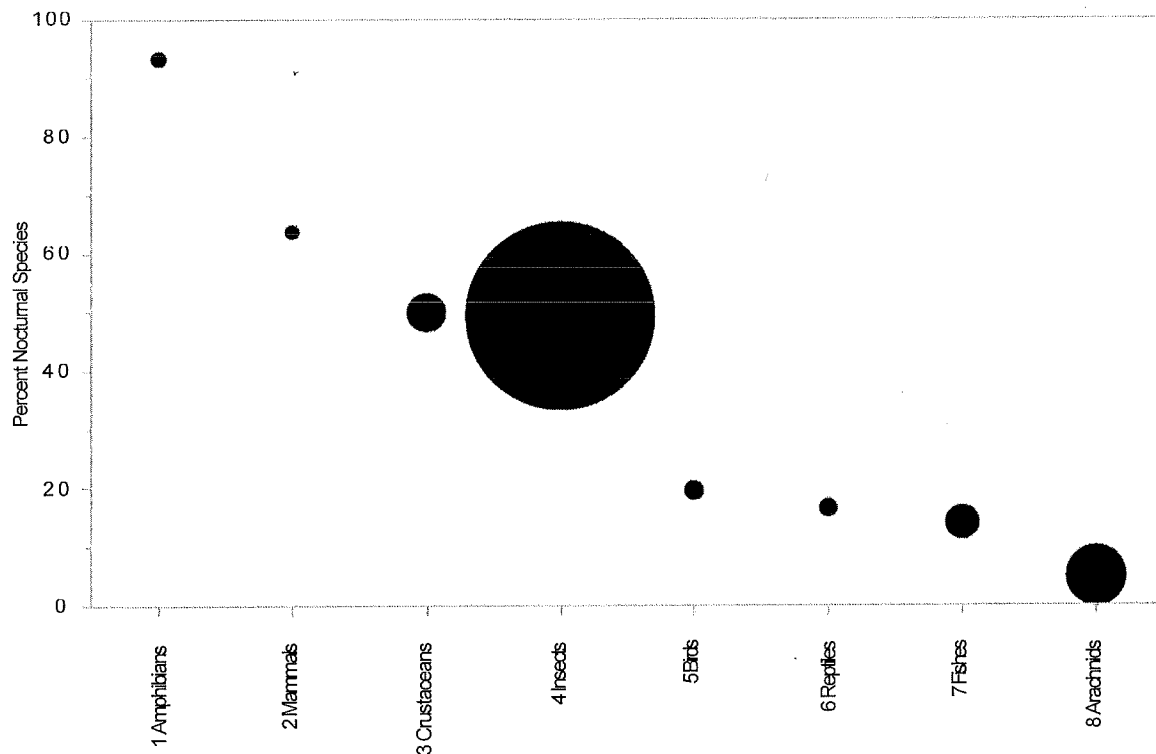


Figure 3. Size Proportion of major animal groups that are nocturnal. Area of markers is proportional to the number of species known in the group. Data from Hölker et al. (2010).

The disruptions caused by artificial night lighting occur whenever the natural patterns of light and dark are changed. This means that very low lighting levels (far below that of the full moon) can have important effects.

Reviews of the effects of artificial night lighting on different taxonomic groups can be found in Rich and Longcore (2006). Resource managers dealing with questions about specific groups of organisms should consult this source, which contains chapters on mammals, birds, reptiles and amphibians, fishes, invertebrates, and plants. Taxonomically specific information is essential to devise lighting systems that minimize impacts on sensitive species when lighting is necessary. Sensitive species should be identified relative to a specific area and might include both those species that have a formal designation as being threatened or endangered or any species of concern that would be sensitive to

changes in nocturnal illumination. Nocturnal, crepuscular, and diurnal species can be affected by nighttime lighting conditions.

In the sections that follow, we present short reviews of the effects of artificial night lighting in different habitat types.

Coastal dunes, beaches, and shorelines

Coastal dunes and beaches are generally open environments with low vegetation adapted to moving sand (**Figure 4**). Dunes present unique environmental conditions that are often quite distinct from their surroundings, and they are often populated by endemic species that thrive in these unique conditions. Coastal endemic species are often a focus of management concern because of the development pressure on coastal ecosystems in the United States (Schlacher et al. 2007a). Dunes are also ecological transition zones between land and water; light from development in coastal dunes illuminates adjacent water bodies, and animals such as turtles move from water to land to nest. Shorelines are essential for organisms such as amphibians and aquatic insects that have biphasic life cycles.

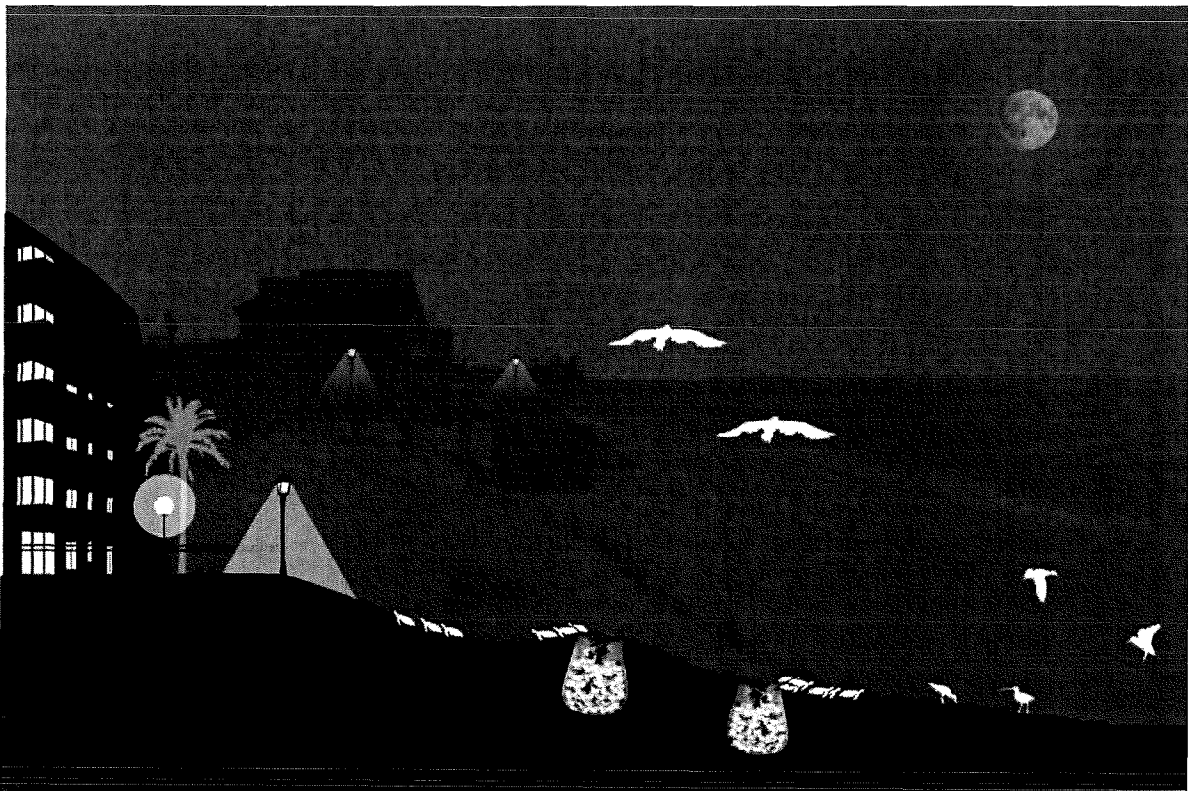


Figure 4. Beach environments are vulnerable to the effects of anthropogenic light because of their open nature. Hatchling sea turtles are easily disoriented by onshore lights or sky glow and patterns of nocturnal foraging by shorebirds are also affected.

On a beach or coast under natural conditions, the view toward the land is almost always darker than the view toward the water. This is a function of landward vegetation and topography blocking light

from the sky (Salmon 2006), in addition to moonlight and starlight reflected off the water. Organisms can use this pattern for orientation. Artificial lighting on the shore or from cities and other coastal development can reverse the natural conditions; the landward horizon becomes brighter, while the water is darker (Salmon 2006).

Stray light and sky glow from coastal development spread across and into many dune and shoreline environments. As in many environments, nocturnal activity near shorelines is significant (Salmon 2006). Beaches and coasts also regularly experience foggy and high-aerosol conditions, which scatter light and thereby amplify the local effects of lights (Kyba et al. 2011).

Artificial lighting has adverse consequences for sea turtles because the darkest horizon is no longer the landward horizon. Indeed, the lethal effects of lights on sea turtles have led to increased awareness of the adverse effects of artificial night lighting in general. Female sea turtles avoid illuminated beaches as nest sites, and hatchlings are fatally affected by lights visible from beaches (Salmon 2003, 2006). This phenomenon was first recorded by MacFarlane (1963), and aversion of females to lights was confirmed experimentally by Witherington (1992). Habitat degradation by lights is caused both by lights adjacent to dunes and beaches and by regional sky glow (Salmon 2006).

As a general rule, additional light — whether moonlight or anthropogenic light — increases foraging efficiency of predators and reduces activity of prey (Longcore and Rich 2004, Rich and Longcore 2006, Seligmann et al. 2007). This phenomenon has been shown many times in different habitats. On dunes, Bird et al. (2004) investigated the effects of lighting on foraging behavior of beach mice. Bird et al. (2004) used low-pressure sodium lights and yellow incandescent “bug” lights, which are commonly employed on beaches in Florida because they have limited effects on sea turtle hatchlings. They found that foraging by beach mice was significantly decreased in proximity to both types of turtle-friendly lights. Similar behavior by prey species has been shown for both natural and anthropogenic light. For example, ghost crabs are active only at night, and avoid activity under both the full moon (Schlacher et al. 2007b) and artificial light (Christoffers 1986). The exception to this pattern is that prey species that flock or school together can be aided by additional light that facilitates communal vigilance (Nightingale et al. 2006).

Effects from lights on beaches and shorelines may also affect aquatic ecosystems. For example, lights affect the predator–prey dynamics of fishes and marine mammals (Hobson 1965, Hobson et al. 1981, Yurk and Trites 2000, Nightingale et al. 2006).

Shorebirds sometimes forage at night (Dugan 1981, Burger and Gochfeld 1991, Rohweder and Baverstock 1996). Various explanations have been proposed: as a defense against predation (Robert et al. 1989, McNeil et al. 1992, Thibault and McNeil 1994), as a result of slightly higher invertebrate activity on beaches at night (Dugan 1981, Evans 1987), and as a response to visual cues that are available due to higher levels of natural or anthropogenic light (Dwyer et al. 2012). Predator defenses of shorebirds are different during the night compared with the day; in an observational study, some proportion of Dunlins freeze and limit vocalizations as a defense at night while all individuals in a

flock fly away in response to predators during the day (Mouritsen 1992). Owls are the major nocturnal predator of shorebirds and are aided by additional light when foraging (Clarke 1983). Timing of foraging by shorebirds, therefore, probably depends on tradeoffs between risks of becoming prey with ability to detect their own prey. Whether birds are flocking and have sufficient light for the associated communal predator vigilance probably also interacts with these factors.

Artificial night lighting on dunes and beaches can therefore have a variety of effects on species. Predator-prey relations are disrupted and key reproductive behaviors can be inhibited. Beaches and dunes also provide a gateway to adjacent water bodies, which have no barriers to block the propagation of light. Because there is usually less anthropogenic light at beaches and on shorelines than in surrounding urban or suburban areas, park visitors often use beaches and dunes to gaze at the night sky. Beaches and dunes should be kept as free from the influence of artificial lights as possible, with special attention paid to ensuring that any lights installed are absolutely necessary and that no lights are directly visible from the beach and points offshore.

Deserts and scrublands

Deserts and scrublands are open habitats with few barriers to the spread of light (**Figure 5**). Many animal species in hot deserts and scrublands adopt nocturnal behaviors to conserve water and avoid daytime temperature maxima. This shift to nocturnal activity may increase seasonally with higher temperature (Kronfeld-Schor and Dayan 2008). Consequently, artificial night lighting has the potential to change the ecology of these environments by disrupting the natural patterns of light and dark relied upon by a large proportion of fauna.

Desert animals can have narrow preferences for illumination levels. These preferences may be related to foraging opportunities, predation risk, or physiological requirements. For example, *Leucorchestris arenicola*, a trapdoor spider endemic to the Namib Desert, exhibits exclusively nocturnal activity patterns (Nørgaard et al. 2006). Males are active only during dark moonless nights, when they are able to navigate hundreds of meters across dune environments using only faint ambient light from stars, airglow, and zodiacal light (Nørgaard et al. 2006). For a species such as this, addition of illumination from any source in its habitat would eliminate its preferred habitat conditions.

Desert rodents also exhibit specific illumination preferences to manage their risk of becoming prey (Grigione and Mrykalo 2004, Beier 2006). Some species are active at twilight, others after twilight, and some during the darkest periods of moonless nights (Grigione and Mrykalo 2004, Upham and Hafner 2013). Anthropogenic light can disrupt these patterns; even the light from a camp lantern equivalent to a quarter moon ($\sim 10^{-2}$ lux) was sufficient to substantially inhibit foraging by a suite of rodent species (Kotler 1984). Those species vulnerable to this disruption lack other predator avoidance abilities such as exceptional hearing (Kotler 1984, Kotler 1985). Because many desert animals exhibit circalunar patterns in their activities, especially predaceous arthropods such as scorpions (Skutelsky 1996, Tigar and Osborne 1999) and granivorous small mammals (Price et al. 1984, Daly et al. 1992, Upham and Hafner 2013), it follows that any artificial light that produces light equivalent to even a quarter moon can alter these patterns.

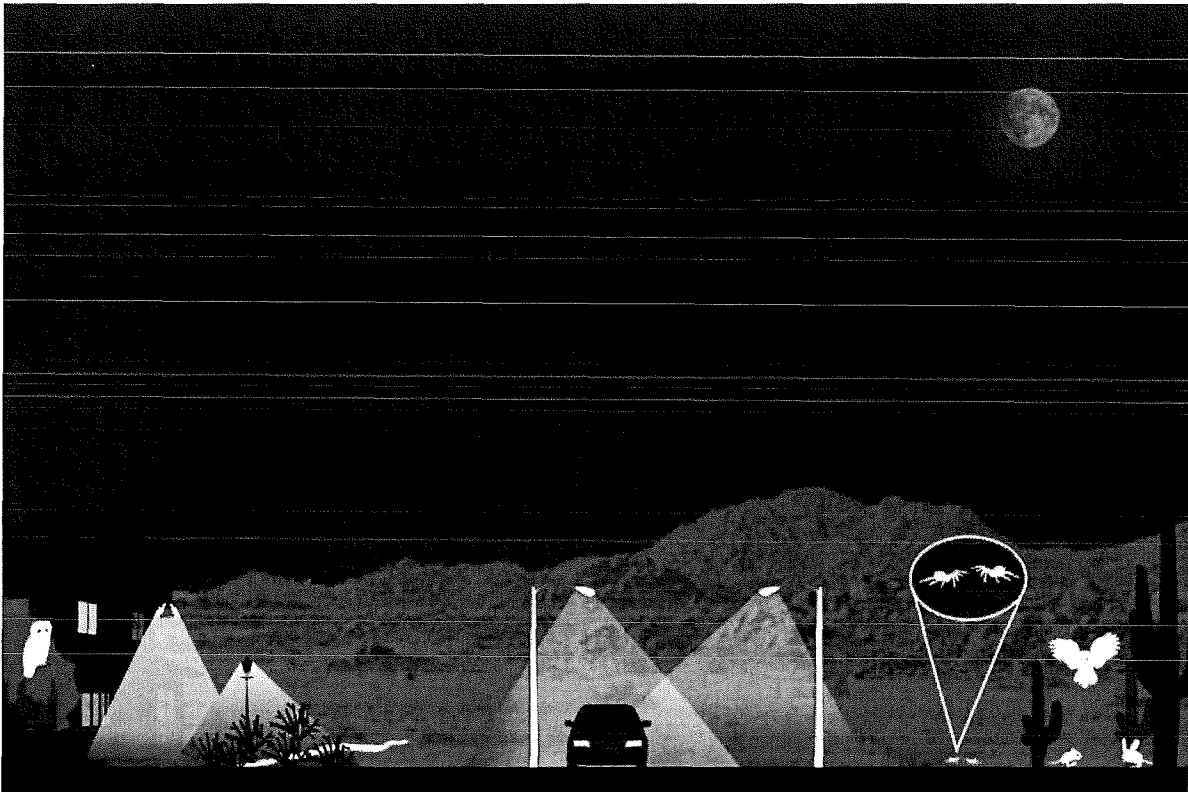


Figure 5. Lights in desert scrublands are visible for long distances and night lighting affects a disproportionate fraction of the wildlife because high daytime temperatures induce nocturnal activity patterns.

Scrubland environments share many characteristics with deserts, especially in Mediterranean climates. A disproportionate number of species is nocturnal at high temperatures, and the open vegetation structure of drier scrublands allows for light to propagate for unusually long distances.

Perry and Fisher (2006) describe the decline of nocturnal snake species in the scrublands of southern California. Long-nosed snake (*Rhinocheilus lecontei*), a nocturnal species, showed a pattern of decline consistent with the gradient of light pollution as estimated by satellite imagery (Fisher and Case, unpub. data). Otherwise suitable scrub habitats, which supported other diurnal species of snakes, lacked long-nosed snakes. The authors hypothesized that decreases in numbers of the snake's small-mammal prey, also associated with light pollution, were responsible for the decline (Perry and Fisher 2006).

Wetlands and rivers

In some places, wetlands and lakes are the last refuges of a natural night on the landscape (**Figure 6**). The difficulty of developing wetlands often leaves them as the only remaining unlighted sites in urban and suburban regions. Many aquatic organisms depend on daily cycles of light and dark and artificial lights disrupt critical behaviors in many species (Moore et al. 2006, Perkin et al. 2011, Henn et al. 2014).

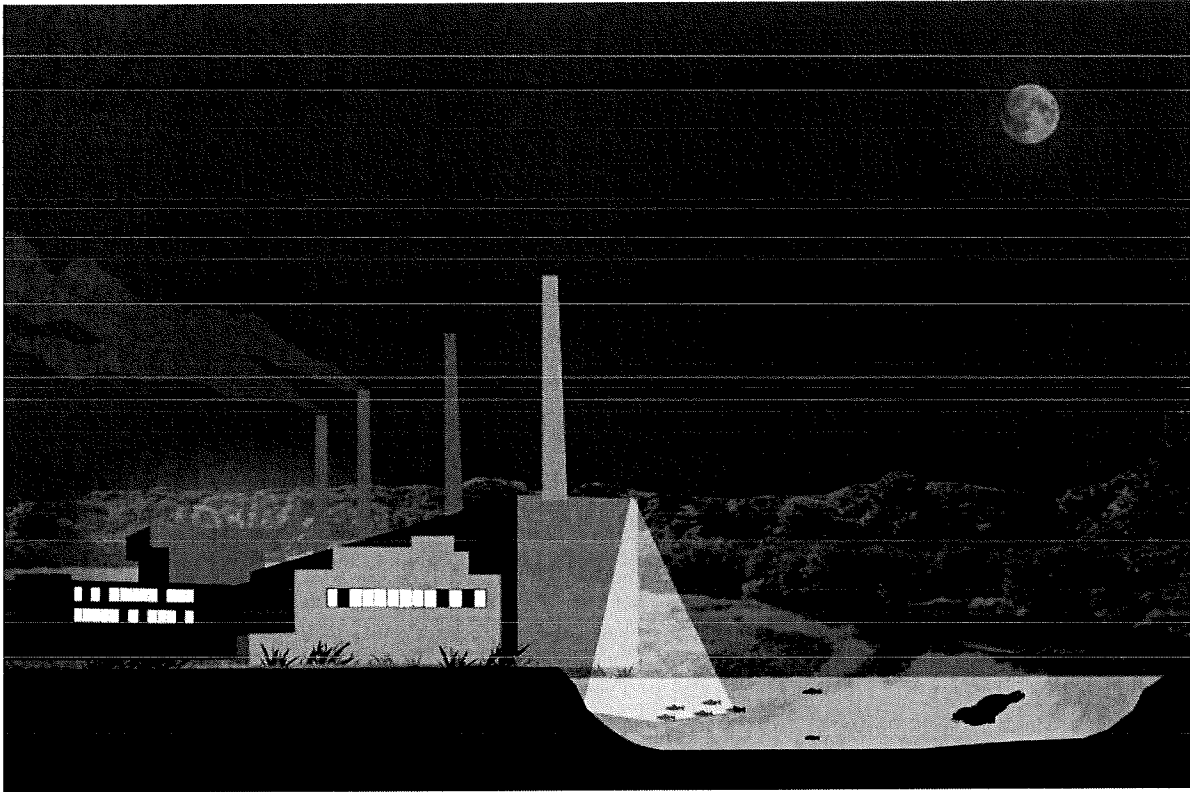


Figure 6. Lights along rivers and streams can disrupt predator–prey interactions, such as seals hunting salmon under lights.

Wetlands are often geographically fragmented, occurring as isolated patches or as linear features stretching across the landscape. Linear features are susceptible to disturbances such as artificial night lighting because they have a high edge-to-area ratio. They also tend to induce development along their edges, which leads to lighting from urban development on either side. Similarly, small wetlands are especially vulnerable to disturbances from their surroundings.

Aquatic invertebrates are important components of wetland ecosystems and provide an example of the sensitivity of wetlands to lighting levels (**Figure 7**). Many aquatic invertebrates migrate up and down in wetlands during the course of a night and day. This “diel vertical migration” presumably results from a need to avoid predation during lighted conditions so many zooplankton forage near water surfaces only during dark conditions. Light dimmer than that of a half moon ($<10^{-1}$ lux) is sufficient to influence the vertical distribution of aquatic invertebrates, and indeed diel vertical migration follows a lunar cycle. When constant light from human development is added to the natural nocturnal illumination of the moon and stars, the darkest conditions are never experienced, and the magnitude of diel migrations (both range of vertical movement and number of individuals migrating) is decreased, which has been shown experimentally for *Daphnia* (Moore et al. 2000). Disruption of diel vertical migration by artificial lighting may have significant detrimental effects on ecosystem health. Moore et al. (2000) conclude that “[decreases in] 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).”

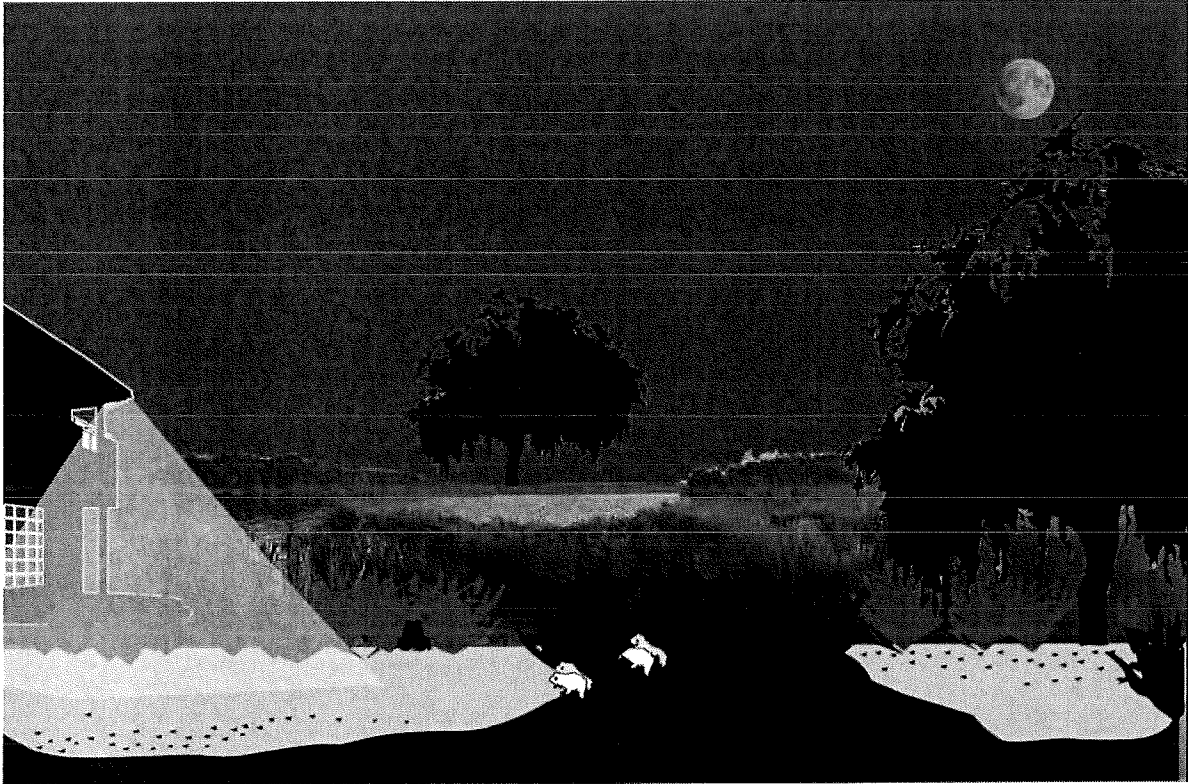


Figure 7. Light in wetlands can suppress diel vertical migration of zooplankton and influence foraging behavior of amphibians.

Amphibians found in nearshore and wetland habitats also are particularly vulnerable to artificial lighting. Amphibians are highly sensitive to light and can perceive increases in illumination that are impossible for humans to detect (Hailman and Jaeger 1976). A rapid increase in illumination causes a temporary reduction in visual acuity, from which the recovery time may be minutes to hours (Buchanan 1993, Buchanan 2006). In this manner, a simple flash of headlights can arrest activity of a frog for hours (Perry et al. 2008). Amphibians are also sensitive to changes in ambient illumination from sky glow. Frogs in an experimental enclosure ceased mating activity during night football games when lights from a nearby stadium increased sky glow (Buchanan 2006). In an experiment to investigate the effects of intermittent artificial light, male green frogs called less and moved more when exposed to the light of a handheld flashlight (Baker and Richardson 2006).

In naturally lit environments, some amphibians will forage only at extremely low light levels, and foraging times are partitioned among species with different lighting level preferences (Jaeger and Hailman 1976). The squirrel tree frog (*Hyla squirrela*) orients and forages at lighting levels as low as 10^{-6} lux and stops foraging at illumination above 10^{-3} lux (Buchanan 1998). The western toad (*Bufo*

boreas) forages only at illuminations between 10^{-1} and 10^{-5} lux, while the tailed frog (*Ascaphus truei*) forages only during the darkest part of the night below 10^{-5} lux (Hailman 1984).

Laboratory experiments indicate that the development of amphibians is influenced by artificial light (Wise and Buchanan 2006, Wise 2007). Light interferes with the production of the hormone melatonin, which is involved in regulating many important functions, including sexual development, thermoregulation, adaptation of eyes to the dark, and skin coloration (Wise and Buchanan 2006, Wise 2007). Current research shows that artificial lighting slows larval amphibian development in the laboratory (**Figure 8**). The influence of artificial lighting on such physiological processes in the field is currently not well known, but the potential for lighting to harm amphibians and other wetland species is evident.

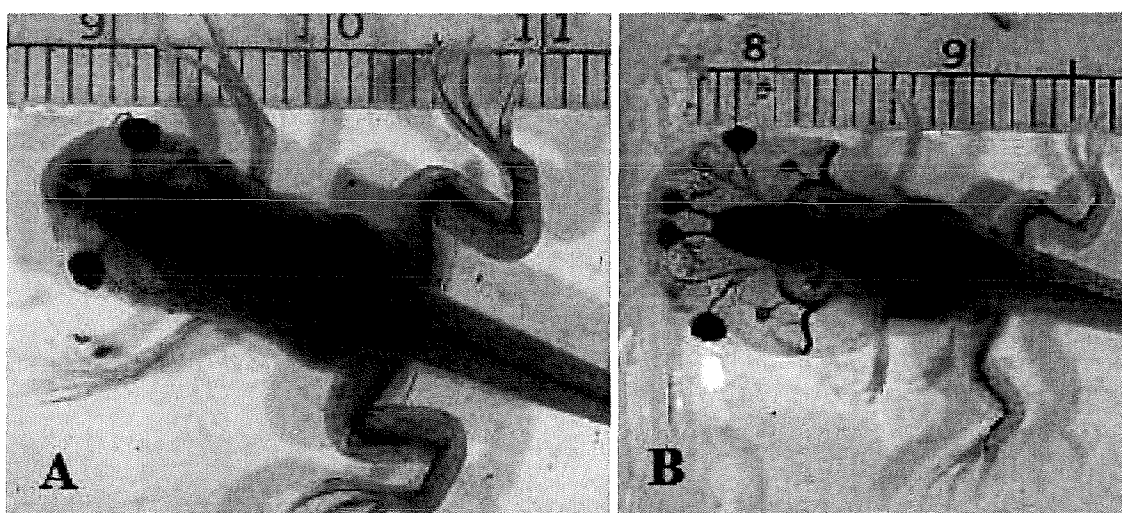


Figure 8. Two tadpoles of the same age and kept in 12:12 L:D lighting. (A) was kept in the equivalent of very dark night (10^{-4} lux) in the dark phase, while (B) was exposed to artificially bright illumination in the dark phase and is not yet metamorphosing (reprinted from Wise 2007).

Fishes are also highly attuned to natural ambient light conditions, with lighting levels influencing the distribution of predaceous species and the foraging behavior of their prey (Nightingale et al. 2006, Becker et al. 2013). Laboratory experiments have shown that the timing of downstream migration of salmon (*Salmo salar*) fry is significantly delayed and disrupted by lights of a similar illumination and spectrum as streetlights (Riley et al. 2013). Nocturnal downstream drift of insects is also delayed by artificial lighting (Henn et al. 2014).

Islands, oceans, and reefs

Light propagates unimpeded across open water, and its reach is extended beyond the curvature of the Earth by reflection off high clouds. Fog can increase local impacts of bright lights. Although light shining directly down on water tends to penetrate rather than reflect, light coming in at an angle is reflected. This physical property of water exacerbates the effects of coastal lighting as it is reflected and propagates out from the shoreline. Island, ocean, and reef environments are affected by artificial

light sources that range from light-assisted fishing to urban sky glow to offshore hydrocarbon facilities (Davies et al. 2014) (**Figure 9**).

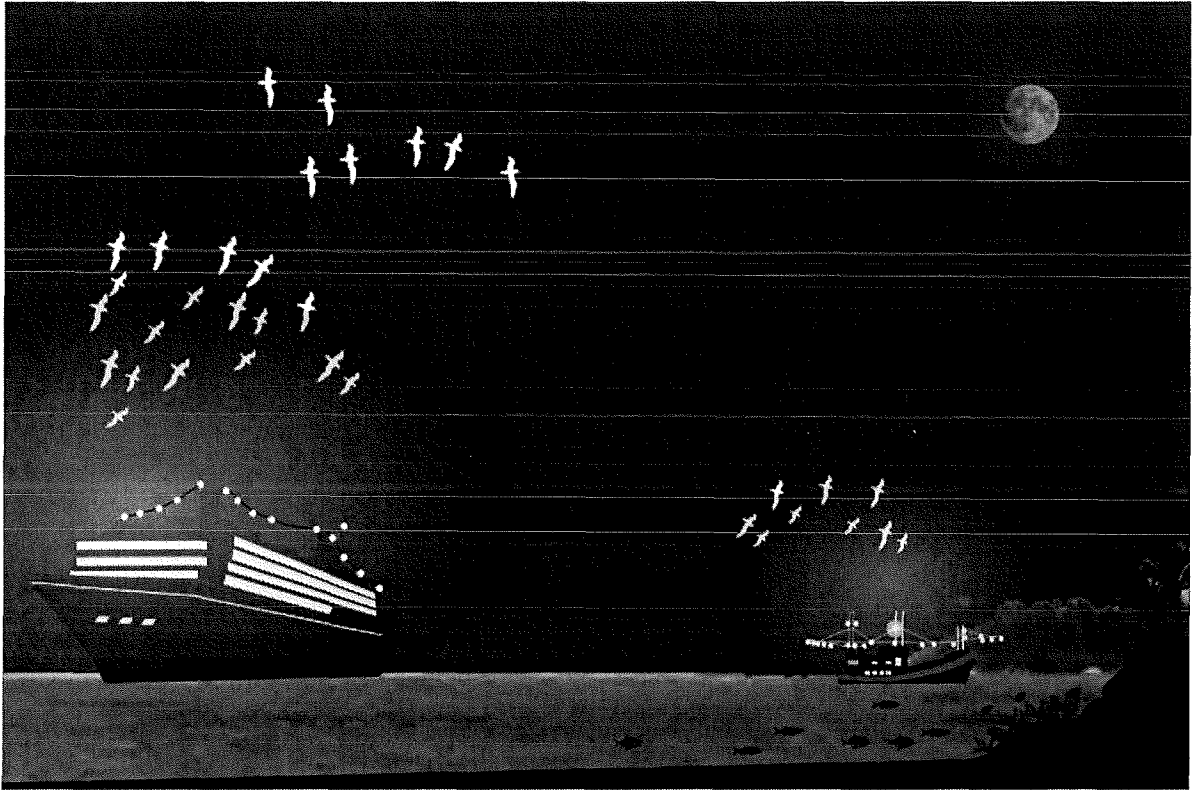


Figure 9. Cruise ships and squid boats are just two of the sources of artificial lighting on the oceans that attract seabirds and migrating songbirds.

In 1999, Xantus's murrelets (*Synthliboramphus hypoleucus*) nesting on Santa Barbara Island, part of Channel Islands National Park off the coast of southern California, were dying at twice the average annual rate. Park managers suspected this increase in mortality was directly related to a recent increase in fishing boats equipped with dusk-to-dawn floodlights to attract squid. Squid boats typically have 30,000 watts of light per boat. The number of squid boats increased dramatically in the 1990s, and in 1999 intense squid fishing occurred during murrelet nesting season (spring, while historically fishing was during fall and winter), and near important murrelet breeding islands. Managers believed that the nesting seabirds, without the safety of darkness, were subject to increased predation, especially from barn owls (*Tyto alba*). During the 1999 season, an unprecedented 165 dead Xantus's murrelets were found on Santa Barbara Island. Most of the dead were killed by barn owls, while five were victims of western gulls (*Larus occidentalis*). Researchers also recorded high nest abandonment closest to the most intensive squid boat activity. Faced with these observations, managers closed the areas around the islands to squid fishing, and death rates for the birds returned to normal. The excluded areas were subsequently incorporated into a permanent marine preserve with no fishing allowed to allow for replenishment of fish stocks. Also, the California Fish and Game

Commission listed Xantus's murrelet under the California Endangered Species Act, citing artificial night lighting as one of the major threats to the species.

Nearly all seabirds are nocturnal, and an adverse response to decidedly unnatural conditions such as those suffered by Xantus's murrelets should not be surprising (Montevecchi 2006). Years of studies have shown that nocturnal seabirds are less active during moonlit nights, and those that are active suffer more predation during those times. Seabird chicks are directly affected by lighting levels; they are far less likely to be fed by adults during bright nights (Riou and Hamer 2008). Seabirds are attracted to lights perhaps because they naturally cue in on bioluminescent plankton to find prey (Montevecchi 2006). They have, therefore, long suffered from collisions with light sources on and adjacent to the ocean, including lighthouses, cruise ships, fishing vessels, lighted buoys, oil derricks, and streetlights on and near islands where they nest (Rodríguez and Rodríguez 2009, Rodrigues et al. 2012, Wilhelm et al. 2013); many of these collisions are fatal. Where lights correspond with critical habitat or high-use zones such as feeding or breeding areas, or migratory routes, the effects could be significant.

Other sources of artificial night lighting threaten the nighttime environment of the oceans. Cruise ships are pervasive, large, and are often brightly illuminated. Ships in the path of bird migrations, or near undersea food sources, may attract both migratory birds and foraging seabirds, which collide with the ships and can be stunned or killed. Anecdotal accounts have emerged where cruise ship staff frantically work to clear the decks of dead birds before passengers awake in the morning. Offshore hydrocarbon extraction platforms are also significant sources of light, and attract and kill birds through collision, exhaustion, and even by incineration in flares burning off natural gas. Many of these birds are long-distance migrants, and the losses at oil platforms may affect regional and global breeding populations.

Coral reefs are also threatened by artificial night lighting. Lighting has been used as a proxy for other impacts (urban development, intense fishing, hydrocarbon extraction) to assess risk to coral reefs on a global scale (Aubrecht et al. 2008). Aubrecht et al. (2008) also illustrated how artificial lighting would adversely impact reefs directly. Corals themselves are highly sensitive to light and synchronize spawning according to lunar cycles (Jokiel et al. 1985, Gorbunov and Falkowski 2002). Many coral reef species exhibit marked light-driven diel cycles or synchronize reproduction by monthly cycles (Sebens and DeRiemer 1977, Bentley et al. 2001, Levy et al. 2001). Predator-prey interactions are influenced by light levels, with diel vertical migration of both zooplankton (Yahel et al. 2005) and planktivorous fishes observed (Leis 1986). Natural light signals, such as bioluminescence, are important to marine organisms (Johnsen 2012), and can both attract and repel fishes (Holzman and Genin 2003, 2005). Artificial lighting at similar and greater intensity must affect a range of marine organisms. Experimental investigation has now confirmed that lighting affects the colonization of marine invertebrates on surfaces (Davies et al. 2015).

Grasslands

Like other open habitats, light has few barriers in grasslands (**Figure 10**). Lights can thereby influence both illumination and direct glare over hundreds of meters or more, depending on

topography. Artificial night lighting can be expected to influence habitat use and behavior of grassland species.

The lights of a road bisecting wet grassland in the Netherlands were shown to influence the spatial distribution of black-tailed godwit (*Limosa limosa*), a rare ground-nesting bird (De Molenaar et al. 2000, De Molenaar et al. 2006). When road lights were turned on during a breeding season, the birds nested slightly farther away from the road, with the effect extending 300 m (984 ft) from the lights. Birds that arrived first to the breeding area nested farther from the lights while those arriving later nested closer (De Molenaar et al. 2000, De Molenaar et al. 2006). The same research group investigated the behavior of mammals in wet grasslands and showed that some species (**polecat**, *Mustela putorius*, **stout**, *Mustela erminea*, **weasel**, *Mustela nivalis*, and fox, *Vulpes vulpes*) were more likely to take paths near lights, while other species were not influenced or preferred darker areas (De Molenaar et al. 2003). Such differences in habitat use have the potential to change predation rates and distribution of prey species as well (Lima 1998).



Figure 10. Grasslands are vulnerable to disruption from even distant lights because of their open character. Fireflies, often found in wet grasslands, can have their signals disrupted or be excluded by high illumination, while some grassland bird species, such as black-tailed godwit (*Limosa limosa*), have been shown to avoid streetlights in selecting nest sites (De Molenaar et al. 2006).

Fireflies are another group of grassland species that can be adversely affected by artificial night lighting (Lloyd 2006). Because light is used for firefly communication, both for sexual behavior and

in some interspecific interactions (where females attract males of other species to capture and eat them), any disruption of the ability to see light will have adverse effects. Artificial light washes out the signals used for communication and is potentially contributing to the decline of fireflies and other organisms that rely on bioluminescent communication (Lloyd 2006, Hagen and Viviani 2009, Bird and Parker 2014).

Deciduous and evergreen forests

Although the structural complexity of forests blocks light and reduces its propagation, species that inhabit the forest floor are sensitive to illumination at levels appropriate to the darker nighttime environment there (**Figure 11**). A review of the research on forest species shows some general patterns that illustrate the potential for lights to affect wildlife behavior.

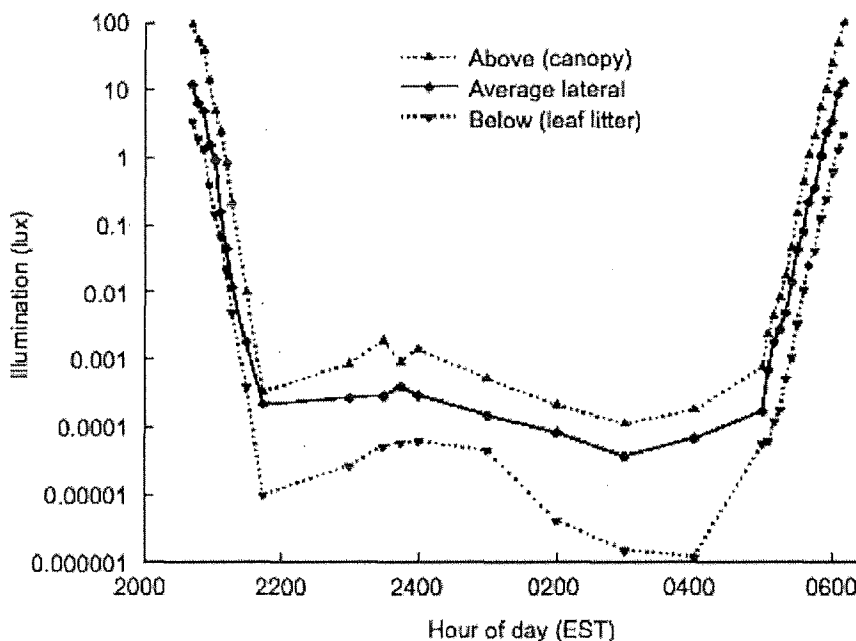


Figure 11. Illumination in deciduous forest (Buchanan 2006). Reprinted with permission.

As in many other ecosystems, salamanders in forests exhibit reactions to light equivalent to moonlight, under which foraging is reduced or delayed (Wise 2007) (**Figure 12**). This has been shown experimentally with dim artificial lights installed in a forest environment (Wise 2007). In two different experiments, lighting delayed the emergence time of nocturnal mammals (DeCoursey 1986, Barber-Meyer 2007) and reduced foraging activity (Barber-Meyer 2007). For sugar gliders, a nocturnal forest mammal native to Australia, light equivalent to that produced by streetlights (7–12 lux) reduced the time individuals were active at night (Barber-Meyer 2007).

In other instances, reproductive behavior can be affected by artificial lighting. The leafcutter ant *Atta texana* usually undertakes nuptial flights approximately 15 minutes before dawn, but in instances where security lights from homes and businesses were visible, the colonies flew 15 minutes after dawn (Moser et al. 2004). This change in timing interferes with behaviors that are carefully

synchronized across colonies. Furthermore, artificial lights are also attractive to the flying ants and, as a result, may both decrease mating success and increase predation at the lights (Moser et al. 2004).



Figure 12. Species of the deciduous forest are adapted to the lower light levels found under the canopy. Flying squirrels and salamanders will delay their foraging under artificial lights.

Alpine and tundra habitats

Alpine and tundra habitats are disproportionately represented in parks and other protected lands. They are on average less developed than other habitat types but can be, and are, developed for recreational and industrial infrastructure. Control of artificial lighting in alpine and tundra habitats is important to avoid disruptions of predator-prey interactions and to avoid disrupting annual rhythms that are entrained by day length.

The topography of mountainous habitats also makes them vulnerable to sky glow from distant sources (**Figure 13**). Because sky glow brightens horizons, areas of steep slopes are positioned to be exposed to that light. In these locations, the aspect of the slope becomes important. Those facing bright horizons will be substantially brighter than nearby locations facing a different direction and therefore will be exposed to far less artificial lighting.

As in other habitats, predator-prey interactions in alpine environments are mediated by illumination (**Figure 14**). For example, small mammals of rocky outcrops typical of alpine regions are often nocturnal, foraging in open areas at night and retreating to the safety of outcrops for shelter (Kramer

and Birney 2001). In experimental conditions one such species, long-eared mouse (*Phyllotis xanthopygus*), foraged less under 1.5 and 3.0 lux treatments (up to very bright moonlight) when compared with a 0.0 lux control (Kramer and Birney 2001). Similar results have been found for snowshoe hares (Gilbert and Boutin 1991), which are subject to more predation under brighter nocturnal conditions, especially during the winter (Griffin et al. 2005). Such small mammals depend on natural darkness for foraging to keep up body weight (Vasquez 1994).

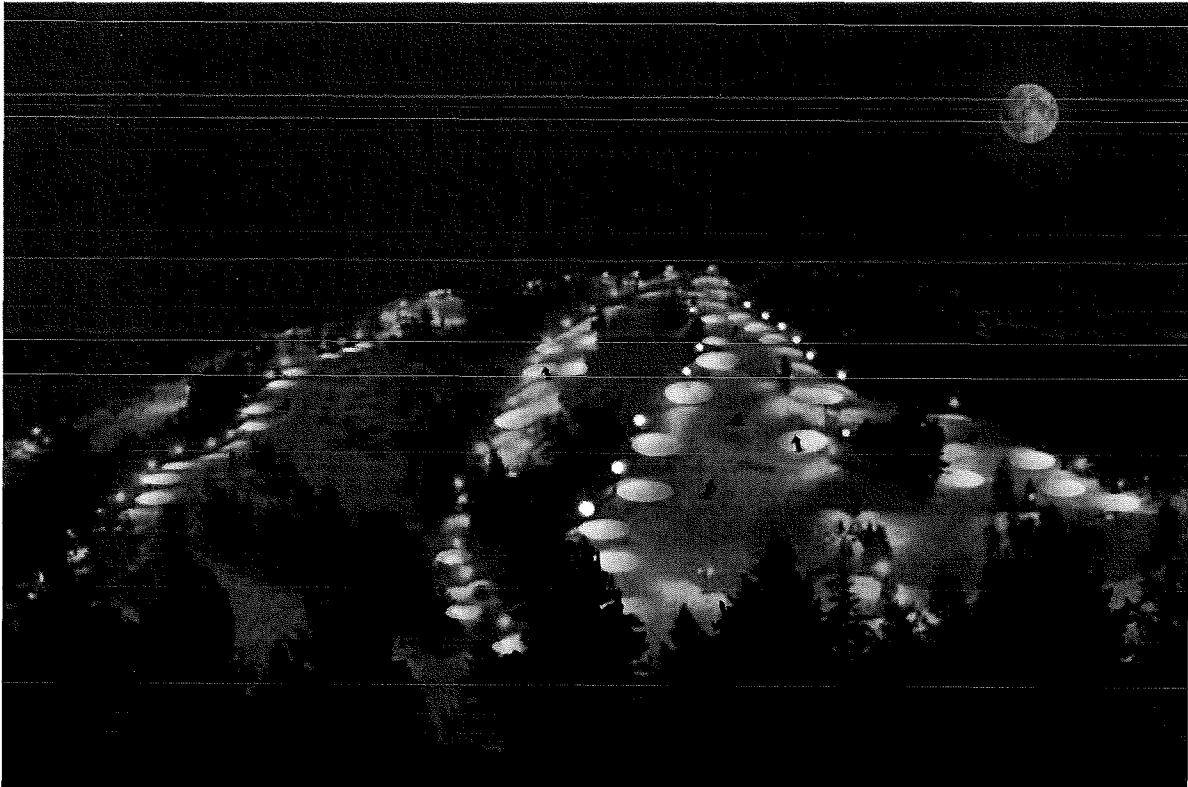


Figure 13. Alpine habitats can be affected by distant lights and those from recreational and industrial facilities.

Circannual rhythms are found in most animals, but the environmental conditions that influence them are less well understood because of the long period necessary to conduct experimental research (Beier 2006). Light appears to have a large influence in setting these cycles, although temperature is also important (Beier 2006). Light can be important in determining when species react to the seasons (e.g., hibernation, Hock 1955), and consequently disrupting these signals has the potential to put species out of phase with climate. In alpine and tundra environments, where conditions change so dramatically between the seasons, appropriate synchronization of activities is important. For example, reindeer (*Rangifer tarandus*) eyes change seasonally to reflect different wavelengths of light; color of the tapetum lucidum shifts from yellow in the summer to blue in the winter, which is associated with increased retinal sensitivity during the dark winter nights (Stokkan et al. 2013). Captive reindeer exposed to sodium vapor streetlights, not directly visible but just over the horizon,

are reported to have green eyes in the winter, not completing the normal transition from yellow to blue, and with reduced visual sensitivity (Yong 2013).

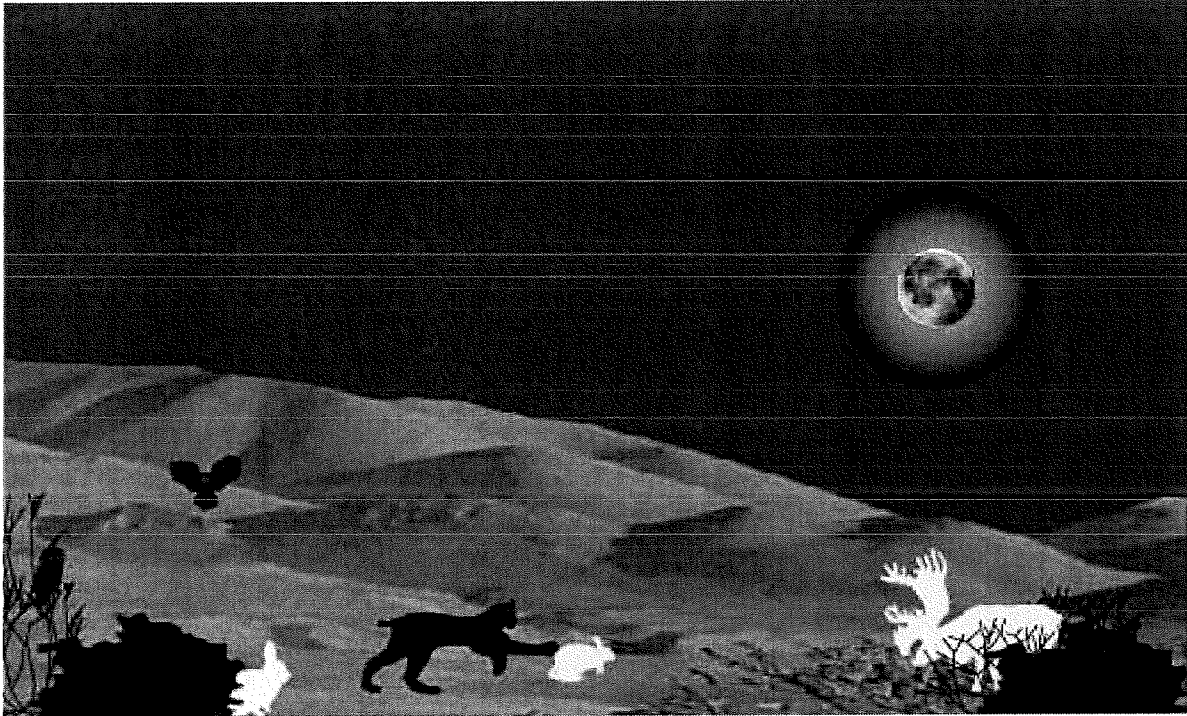


Figure 14. Predator–prey interactions are affected by artificial lights during long nights on the tundra.

Urban environments

Even though urban environments have many sources of artificial lighting at night, variations within already light-polluted environments still make a difference to wildlife (**Figure 15**). For example, American crows (*Corvus brachyrhynchos*) choose roost sites in urban areas that are on average more brightly illuminated than non-roost sites (Gorenzel and Salmon 1995). Presumably, this allows the communal predator response behaviors of the flock to operate more efficiently, reducing predation from owls. Elevated populations of this native species have adverse consequences for other native species for which the crows are predators. In another example, urban-tolerant bat species are influenced by the degree of illumination on the exit hole of their roosts. Nightly emergence is delayed by illumination of the exit hole, which reduces fitness of individuals in the colony and can eliminate the colony altogether (Boldogh et al. 2007). Because of the importance of bats as consumers of insects, and their conservation status, the adverse impacts of lighting are concerning (Stone et al. 2015).

Cities are also sites of mortality for nocturnally migrating birds, which are attracted to lights. Birds die either in collisions with buildings at night, or during the day when they attempt to regain their orientation and continue migration. This phenomenon is well documented in Chicago, Toronto, New York, and Washington, D.C. A notable example in a national park is the ongoing mortality of

nocturnal migrant birds at the Washington Monument, which started when it was illuminated (Overing 1938).

The profusion of light in urban areas also has spillover effects on surrounding natural areas and open spaces within cities. For example, extremely high levels of ambient light are measured in the Santa Monica Mountains National Recreation Area near Los Angeles, with all-sky brightness exceeding natural levels by 18.4 times and maximum nocturnal vertical illuminance 32.4 times brighter than natural levels (J. White and C. Moore, pers. comm.). Although it is difficult to address the multitude of sources of light, it is worthwhile for parks to incorporate lighting and the night sky as part of their education, outreach, and engagement in communities adjacent to and near parks (Aubé and Roby 2014).

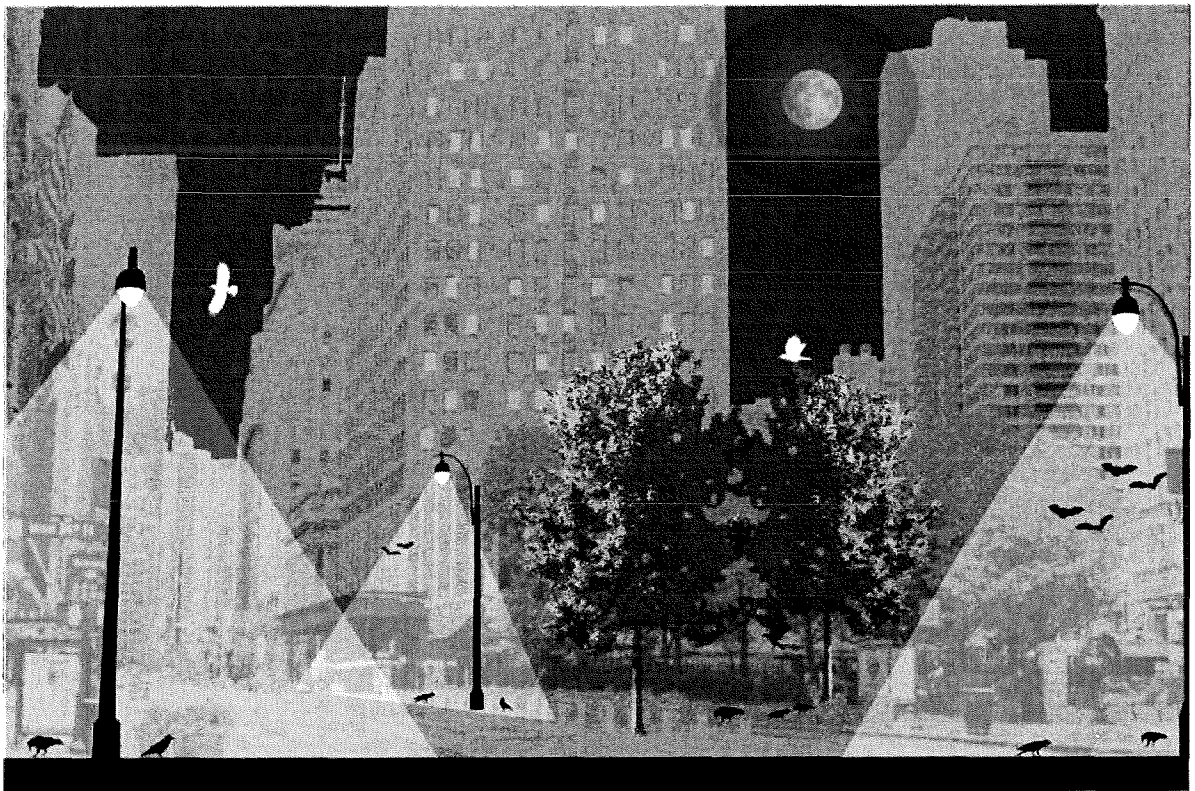


Figure 15. Cities are affected by altered light environments, which are exploited by synanthropic species such as crows and some bat species.

The evidence from across habitat types indicates that artificial lighting at night is either proven to, or has the potential to, disrupt the natural behavior of wildlife species, sometimes with lethal consequences. From this context we can identify practices that can reduce and minimize the effects of lighting in parks and other lands managed for natural resource values.

Mitigating the Effects of Lighting on Protected Lands

Knowledge about the effects of lighting on wildlife continues to grow. All indications are that lighting can have cumulative and additive consequences that are especially important for vulnerable species. Many general approaches to minimizing the effects of artificial lighting on wildlife are known. To reduce effects on certain target species, these mitigations may need to be adapted to craft desirable solutions for specific locations. In the following two sections, considerations for developing such mitigation measures are discussed. First we introduce the attributes of nighttime lighting that might be manipulated — spectrum, intensity, direction, and duration — and how different groups of species might be affected by them. Then we review the many contexts in which light is used (e.g., security lighting, vanity lighting, communication towers) and identify preferred mitigation strategies for them.

Approaches to minimize lighting impacts

The impacts of artificial lighting to wildlife can be reduced in five ways: 1) avoiding use of lighting that is not needed, 2) controlling color spectrum, 3) limiting light intensity, 4) managing the direction of light emissions, and 5) limiting the duration of light output. For some of these characteristics, a single approach applies in all instances. For others, the recommendation depends upon the context of use or the species that might be affected. A combination of mitigation approaches is likely to be more effective (e.g., reducing intensity and adjusting color spectrum) than would be any approach taken individually.

Need

The first question that should be asked about artificial lighting, especially in natural areas, is whether it is in fact needed. In some situations, a creative solution, such as the choice of a pale color for a pathway, curb, or steps, is all that is needed to guide visitors (**Figure 16**). In others, lighting can be left to the visitor to provide in the form of headlights or a flashlight. Only when the need is demonstrated and necessary for visitor experience, safety, or security, should lights be installed.



Figure 16. A pale-colored path can be just as effective as electric lights in some park situations.

Spectrum

It is tempting to believe that a certain spectrum of light will minimize the effects of lighting in all situations. Unfortunately, no universal solution exists. Rather, it is possible to identify spectra of light that have shown to affect wildlife less in certain contexts. The only 100% wildlife-friendly light is one that is switched off or never installed.

The higher efficiency of high-pressure and low-pressure sodium lamps resulted in their widespread adoption in street lighting applications and security lighting, replacing the older mercury vapor lamp technology. Recently, however, full-spectrum light sources such as metal halide lamps, compact fluorescent lamps, and LEDs are becoming more common (Gaston 2013). Full-spectrum lights appear white, in contrast with other lights such as sodium vapor lamps that appear yellow or orange. Earlier technologies, such as mercury vapor lamps, were also full-spectrum, but have largely been replaced by sodium vapor lamps. LEDs are more efficient than older lamps used for outdoor lighting, and have greater color rendition than sodium vapor light sources. This return to white light sources brings certain advantages for human use, but includes a wider range of wavelengths, potentially impacting more species (Stone et al. 2012) and exacerbating sky glow (Aubé et al. 2013).

The combination of colors that make up a full-spectrum light is described by the correlated color temperature (CCT) of the light. CCT is measured in degrees Kelvin and corresponds to the appearance of light that would be emitted from an idealized “black body” if it were heated to that temperature. Lower CCTs are dominated by yellow and other longer wavelengths, while higher

CCTs are dominated by blue and other shorter wavelengths. For example, an incandescent bulb has a CCT of around 2400–2800 K, while a metal halide lamp has a CCT of 4000 K and direct sunlight 4800 K. LEDs are offered in many color temperatures, from 6500 K to 2700 K, and can also contain mixes of colors that do not have color temperatures associated with them (i.e., “off the black body curve”) and are measured in other ways. High-pressure sodium lamps have a CCT of around 1800 K and low-pressure sodium lamps, which are all yellow, do not have an associated color temperature.

One general rule is to avoid any light that has emissions in the ultraviolet spectrum and adjacent short wavelengths. Ultraviolet light is not visible to humans, yet is visible to other species. Insects are highly attracted to ultraviolet light and their attraction and mass death at lights would be dramatically reduced by eliminating ultraviolet light from general use (Frank 1988, Eisenbeis and Hassel 2000, Eisenbeis 2006, Frank 2006). Mercury vapor lamps are high in ultraviolet radiation, while other commonly used outdoor lamps (e.g., metal halide, fluorescent) have some ultraviolet as well. LEDs have no ultraviolet emissions and therefore attract fewer insects than lamps of comparable intensity and color temperature that do have some ultraviolet emissions (Poiani et al. 2015, Longcore et al. 2015).

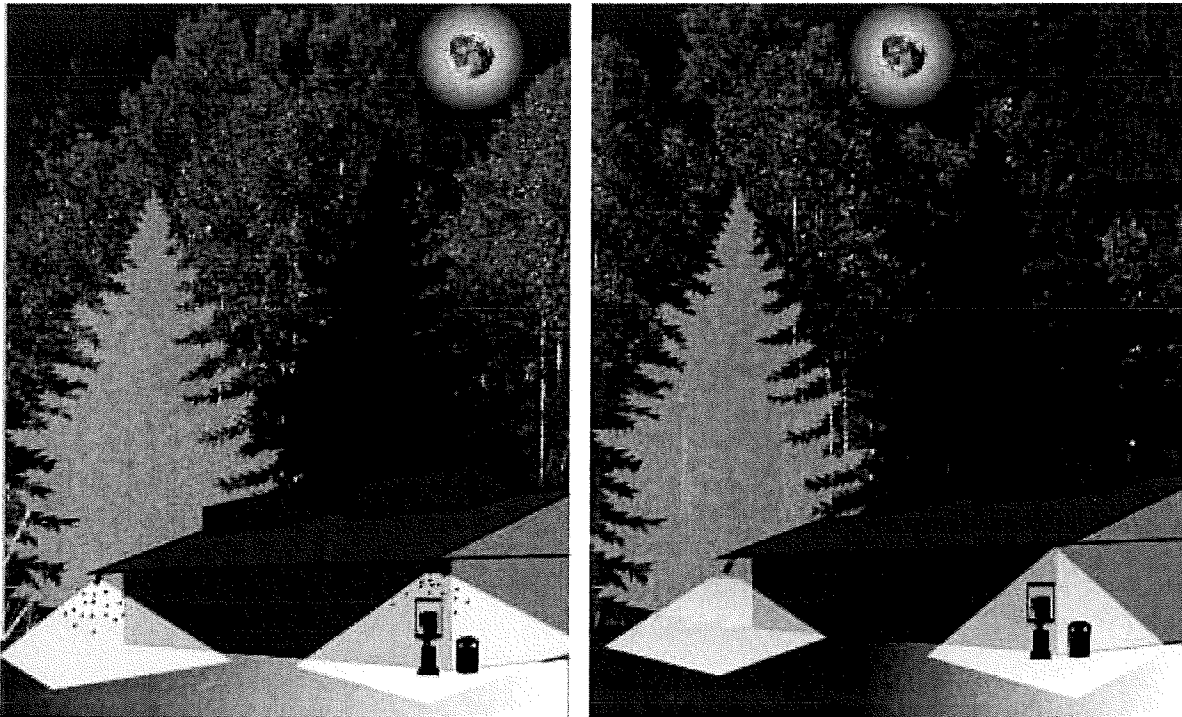


Figure 17. Yellow light that does not contain blue or ultraviolet wavelengths attracts far fewer insects.

Insects are also attracted to light in the short visible wavelengths (e.g., violet and blue) (**Figure 17**). Full-spectrum lighting that allows good color rendering for human vision is not advisable from the standpoint of ecological effects because it contains light in the blue spectrum (Eisenbeis and Eick 2011). All lights heavy in the blue portion of the spectrum, such as fluorescent lights, metal halide lights, and full-spectrum LED lights, will have greater impacts on insects than lights with longer

wavelengths (e.g., low-pressure sodium vapor lamps or yellow/amber LEDs) (Eisenbeis and Eick 2011, Pawson and Bader 2014, Poiani et al. 2015, Longcore et al. 2015). If full-spectrum lighting is required, then the lowest possible color temperature is recommended (Longcore et al. 2015).

Blue light contains the most biologically active wavelengths for physiological processes such as the production of hormones and the timing of daily activities (Beier 2006, Brainard et al. 2015). This concern has been best expressed relative to human health (Pauley 2004, Brainard et al. 2015), but blue light also disrupts circadian rhythms in wildlife. To minimize disruption to circadian rhythms, shorter wavelengths such as blue and violet should be avoided. They might also be avoided to minimize influence on species that are phototactic to blue light, such as many frog species that have a blue light preference whereby they move toward blue light, presumably as an escape mechanism that leads them away from vegetation (and into water) in times of danger (Hailman and Jaeger 1974, Buchanan 2006); these preferences can vary depending on the intensity of illumination, however (Buchanan 2006).

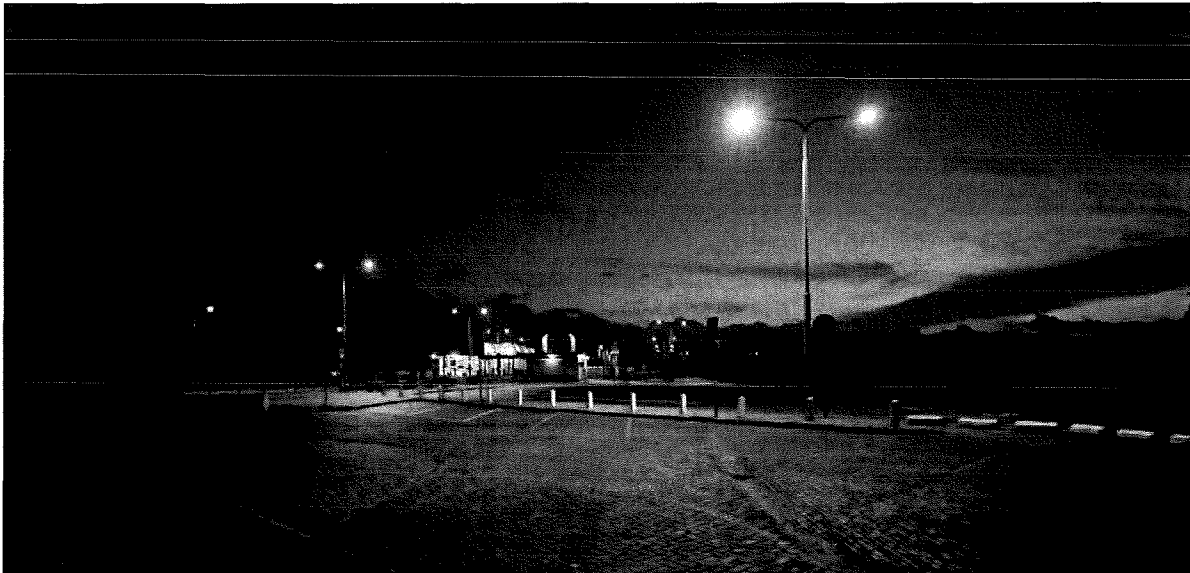


Figure 18. Green lighting designed to minimize attraction of birds developed by Philips. Shell is using these lights on an oil platform in Alaska and Philips is adding the lights to its regular catalog. Photograph courtesy of Joop Marquenie.

Birds are able to orient to the Earth's magnetic field under monochromatic blue or green light, but such navigational ability apparently does not function under lights that are only red or yellow. The molecular mechanism that allows detection of the Earth's magnetic field requires light of a certain wavelength to be activated (Ritz et al. 2009), which presumably explains the inability of migratory birds to orient under light that lacks those wavelengths (Wiltschko et al. 1993, Wiltschko and Wiltschko 1995). Dutch researchers have experimented with the use of specially designed lamps that contain blue and green light at coastal locations and on offshore platforms to see if the number of attracted and disoriented birds is decreased (van de Laar 2007, Poot et al. 2008). Results show blue

and green lights influence birds less than red and full-spectrum (white) light, although the effects on other species have not been documented in the scientific literature (**Figure 18**; **Figure 19**).

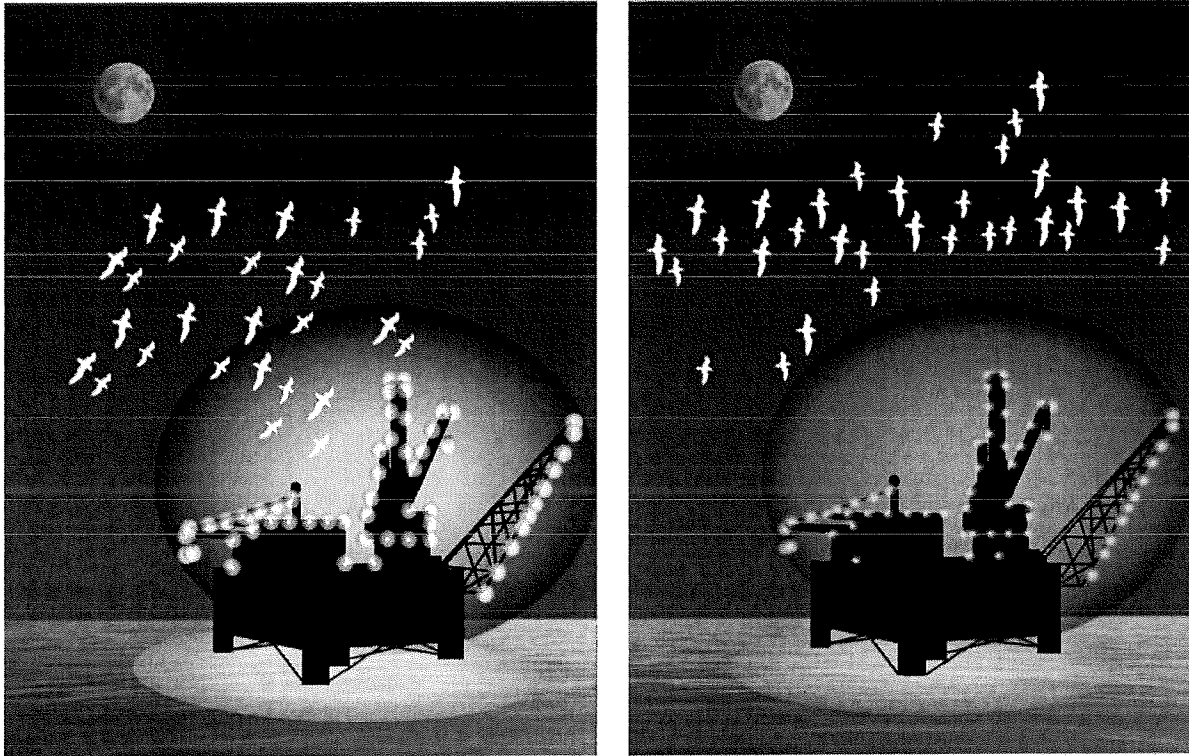


Figure 19. Green lights have been investigated for use on offshore structures and shown to be less attractive to birds.

In other situations, light that includes longer wavelengths appears to attract few insects and does not disrupt orientation of sea turtle hatchlings. For this reason, yellow lights are commonly identified as being wildlife-friendly (**Figure 17**). These same lights, however, reduce the foraging activity of native beach mice (some species of which are endangered) along the Florida coastlines where turtle-friendly lighting is recommended (Bird et al. 2004). Fireflies are vulnerable to impacts from yellow light because it is this part of the spectrum that is used by those species flying after dusk (Lloyd 2006).

Red light appears to disrupt the orientation capabilities of birds, but it seems to have the least effect on other species (**Figure 20**). Few insects are attracted to red light and dark-adapted eyes are not bleached by red light, making it the spectrum of choice for stargazers. In low-light environments in parks, red light might be preferable where lights are needed for safety reasons (**Figure 21**).

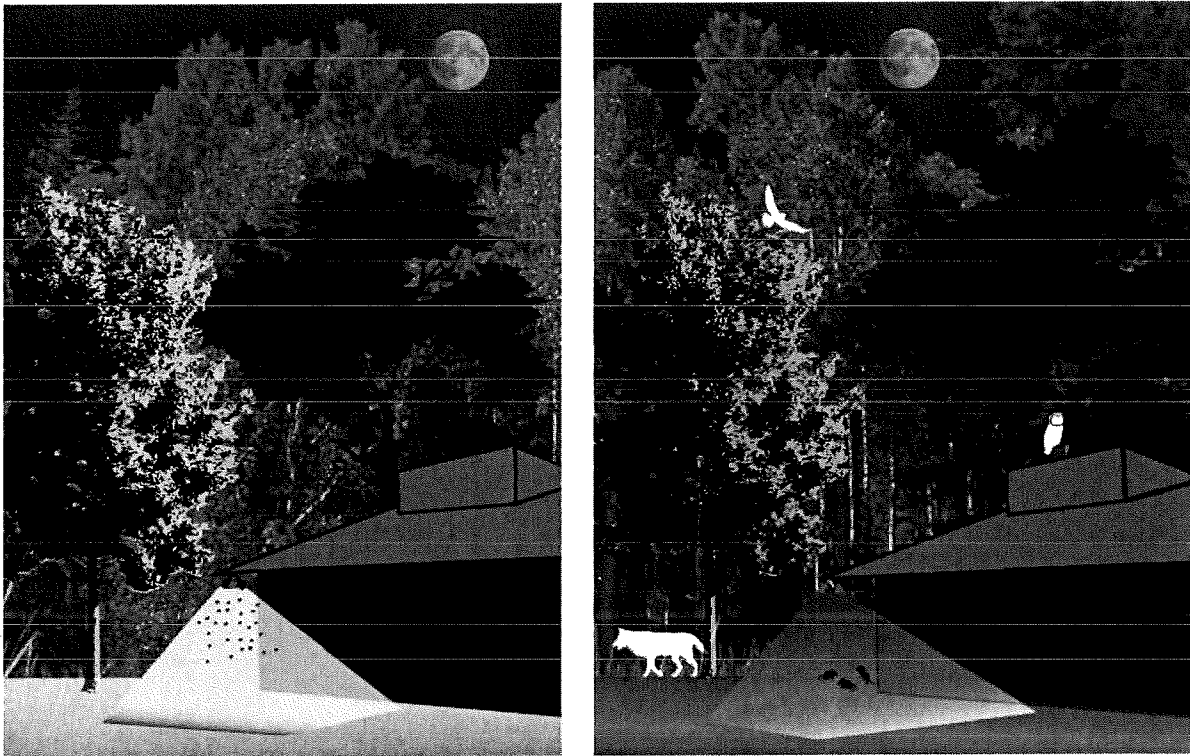


Figure 20. Red light does not disrupt dark-adapted vision and is therefore appropriate for campsites and locations used for astronomical observation.

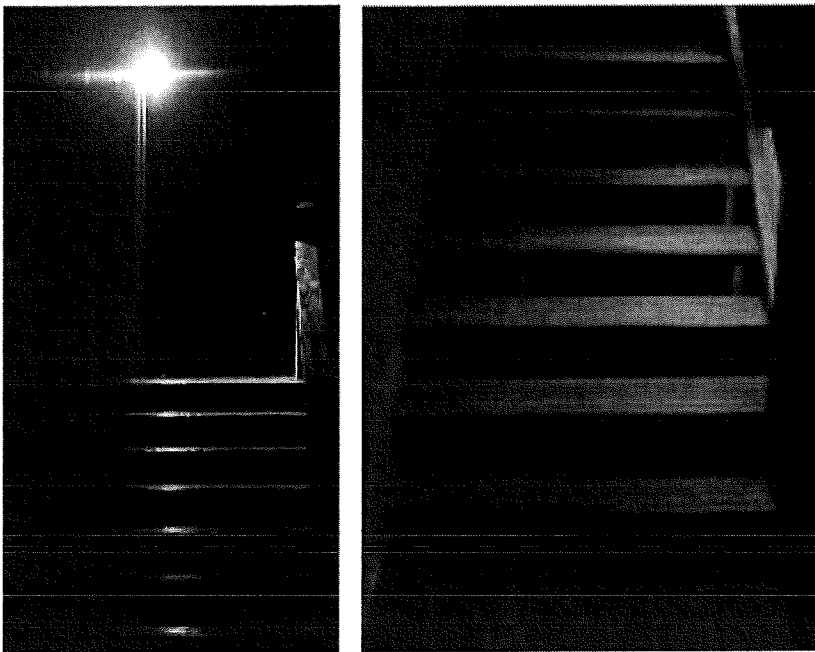


Figure 21. Illumination of a stairway at a campground by two low-intensity red bulbs instead of by a bright white spotlight (Wagner et al. undated).

Through all the considerations for different taxa, a few general lessons emerge to guide use of spectrum: 1) the choice of color significantly affects the degree of biological disruption; 2) narrow-spectrum lights are preferable to broad-spectrum sources (i.e., white light); 3) ultraviolet light should be avoided; 4) blue and shorter wavelengths increase biological responses and generally should be avoided; and 5) concerns about individual species in an area may influence the choice of least disruptive color for lights.

Intensity

Land and facility managers have great latitude in selecting the intensity and quantity of lighting used. From a wildlife perspective, discretion should be exercised to use the minimum amount of light required. This can be accomplished by significantly decreasing the luminous output commonly specified by lighting designers. Land managers should not rely on standards promulgated by professional societies to guide lighting levels for natural areas because these are generally developed for urban/suburban areas with little to no regard for wildlife. Rather, every effort should be made to reduce the intensity of lights and still achieve the desired function.

Reduction in lighting intensity benefits species in the vicinity of lighting and also reduces the reflection of light in the atmosphere. The glow of lighted areas can thereby be reduced, decreasing impacts to natural systems and park visitor experience in wildlands. Often, illumination levels can be reduced without adverse consequence for human activity. In fact, reducing the contrast between light and dark areas increases the ability of humans to see. The human eye adapts to the brightest light in view. As the eye adapts to bright lights, acuity in darker areas is lost. Bright lights plunge the surrounding areas into dark shadows, while with dimmer lights the eye is able to retain some of its ability to see in darker areas.

Direction

Shielding lights is a common mitigation measure to reduce impacts to natural lands and species (**Figure 22**). Usually this involves shielding a fixture so that little or no light is emitted above the horizontal plane, and less than 10% of the light is emitted within ten degrees below the horizontal plane. This is the definition of a full cutoff lighting fixture. Shielding in this manner greatly reduces (but does not eliminate) sky glow. Light still reflects off the ground and scatters, so reduction in intensity should be combined with shielding. Downward-directed lights may still have adverse ecological consequences such as attracting insects and species that feed on the insects (e.g., bats, frogs, birds), or directing light into sensitive habitats such as wetlands and rivers.

Land managers should endeavor to shield lights beyond full cutoff to ensure that light falls only on the intended surfaces. Such mitigation will minimize direct glare, which can affect the orientation of organisms across distances (Reed et al. 1985, Telfer et al. 1987, Beier 1995, Longcore and Rich 2004); this will also minimize the area that is artificially illuminated. Design solutions to achieve these goals include the use of embedded lights to illuminate important surfaces (**Figure 23**) and simple retrofits to shield existing lights (**Figure 24**).

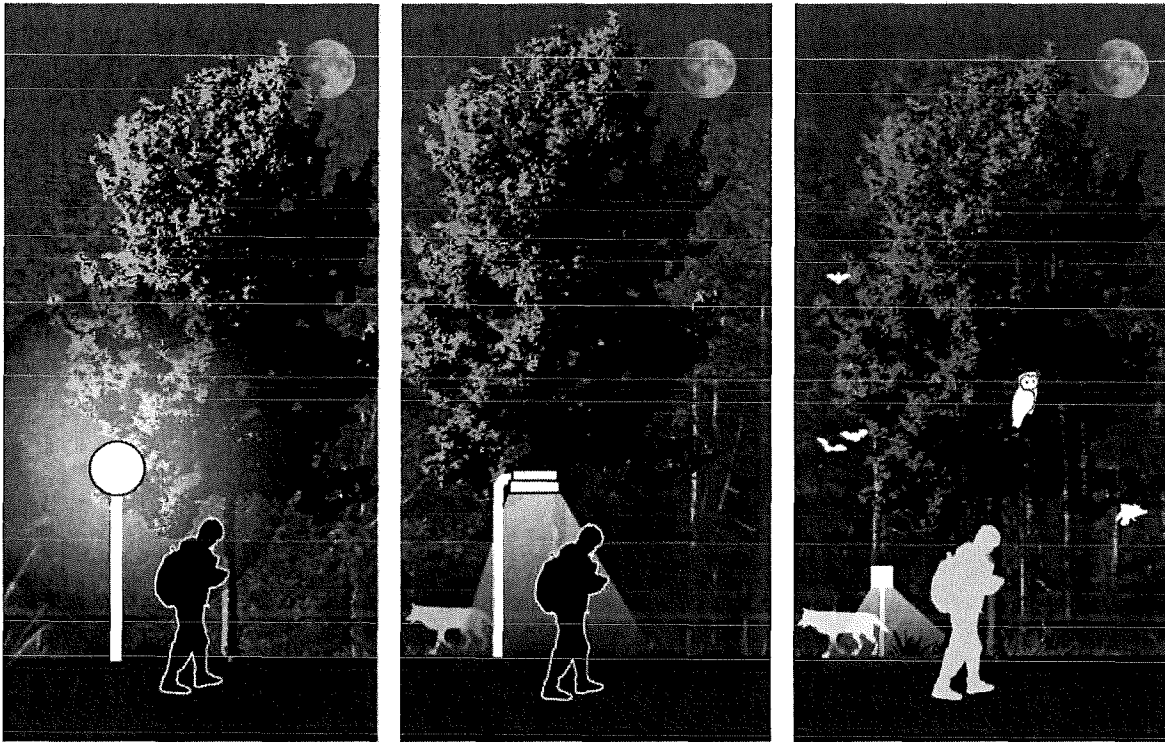


Figure 22. The more focused light can be on its target, the less it will affect other species.

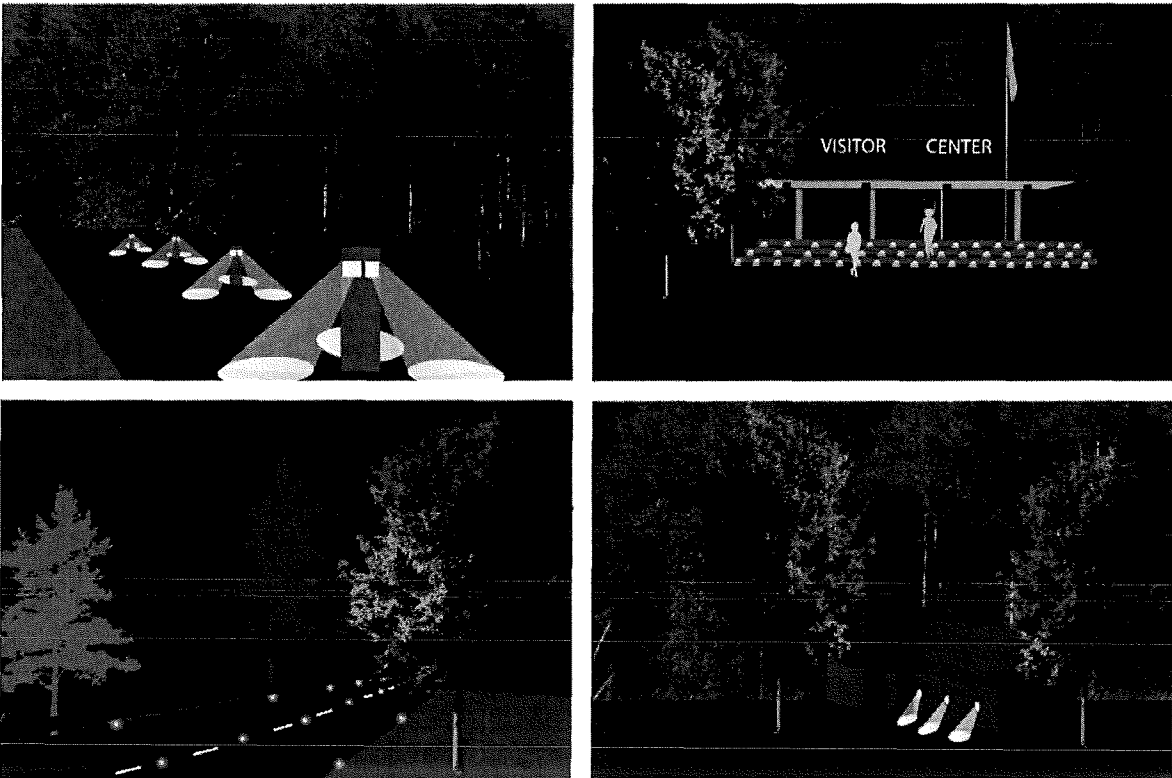


Figure 23. Embedded lights allow wayfinding with minimal intensity and good directional control.



Figure 24. A full cutoff shield being installed on an existing light on the lodge at Yellowstone National Park. This previously unshielded light was visible across the lake and from the backcountry. Photograph by Travis Longcore.

Duration

Impacts from lighting can be reduced by changing the duration of illumination. This approach reduces some impacts, but it may have some adverse consequences for those species sensitive to a changing light environment and so should be implemented with these limitations in mind. One common way to reduce the duration of illumination is to install a motion detector so that a light is only on when there is activity in a particular area (**Figure 25**). Although this limits the amount of time lights are on, lights that go on and off at irregular intervals may disrupt the nocturnal behavior of some species. For example, green frogs (*Rana clamitans*) reduce calling behavior and move away when a light is shined on them (Baker and Richardson 2006); return to a dark-adapted state can take hours (Buchanan 2006).

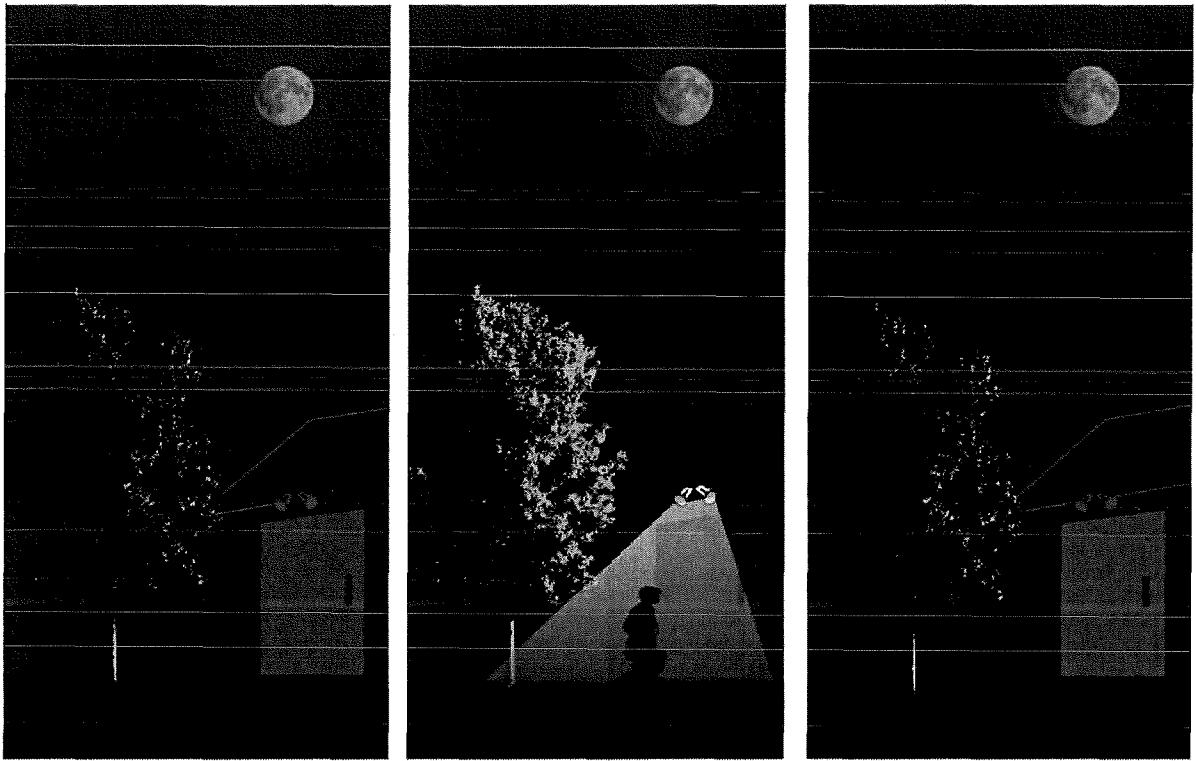


Figure 25. Motion- and heat-detecting lights provide illumination only when it is needed.

Another restriction on duration is setting a time for lights to be extinguished each night (**Figure 26**). For example, the lights that illuminate Mount Rushmore are only on for a few hours each night. This approach, known as part-night lighting, reduces impacts by allowing darkness during the late night and early morning hours. Depending on the timing of the lighting, darkness can be maintained for the majority of the activity period for a target species (Day et al. 2015). This approach, however, may still disrupt activities during the specific light conditions at dusk that are required by other species (Longcore et al. 2003, Day et al. 2015). Rather than a smooth range of illumination conditions occurring as the sun goes down and darkness falls, sites will experience a single illumination level until the lights are turned off. Many groups of species share resources across lighting levels; that is, one species may forage at dusk, another right after dusk, and another in the dark of night (Hailman 1984). Increased illumination, even on a temporary basis at dusk or dawn, reduces the time available for critical behaviors and could eliminate them altogether if a species prefers the transitional lighting levels of dusk when lights are illuminated. If artificial lighting eliminates a significant period of potential activity time for a species, the long-term consequences will be negative. In studies of bats, part-night lighting has been found to be ineffective in avoiding the activity periods of most species in the locations studied (Azam et al. 2015, Day et al. 2015).

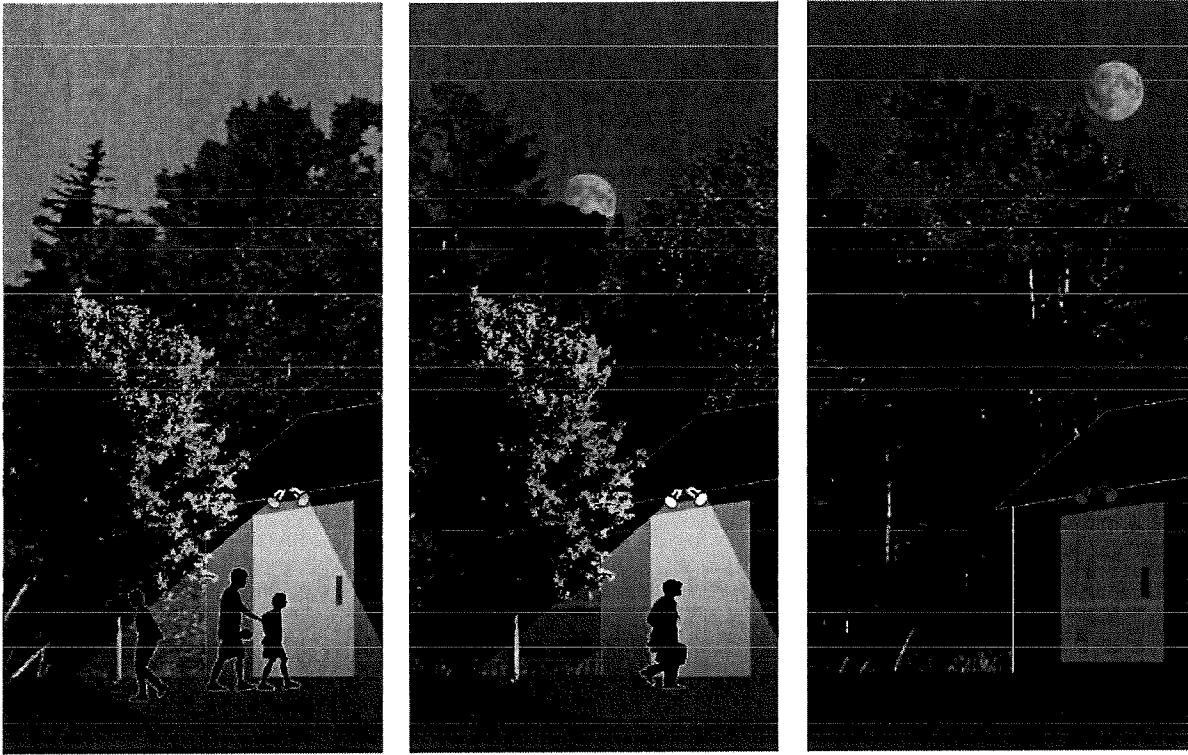


Figure 26. Timed lights may affect species negatively during the transitional period of dusk, but may reduce impacts later at night.

There may be instances where avoiding lighting during a particular time when animals are active is an appropriate way to mitigate impacts. Many species are active during the crepuscular periods of dusk and dawn. If lighting can be avoided until after dark, or closer to dark, certain impacts on those species might be avoided. Setting photodetectors to activate lights only at very low levels of illumination will avoid the biologically active crepuscular period, reduce insect attraction, and limit light to after civil twilight when it is really needed.

Whenever lights are required, reducing their intensity or turning them off during periods they are not needed should always reduce impacts. For example, the Dutch government has mitigated lighting impacts on sensitive wet grassland habitats by turning off roadway lighting at 11 P.M. and replacing it with 7-watt incandescent bulbs halfway up the light standards (De Molenaar et al. 2006). These lights allow for wayfinding and have not changed the number of accidents occurring on the road.

Lighting situations

In addition to controlling for spectrum, intensity, direction, and duration, mitigation measures can be devised for many other situations in which lighting might be installed in parks. In the sections that follow, we discuss the issues involved with mitigating impacts from a series of different situations that might be faced by a park manager.

Communication towers

Each tower in the United States that is taller than 200 ft (61 m) must have obstruction lighting in accordance with Federal Aviation Administration (FAA) guidelines. Lighting is a primary factor resulting in the attraction to and mortality of birds at towers. An estimated 6.8 million birds per year are killed at tall towers (Longcore et al. 2012), including many species of conservation concern (Longcore et al. 2013). Reviews of previous work, and subsequent studies, have shown that mortality can be reduced by using a lighting system that has flashing lights only, whether these are strobe lights or red flashing lights (Gehring and Kerlinger 2007). White strobe lights have long been approved as lighting on towers and the FAA has updated its regulations to allow red flashing lights only (see FAA Advisory Circular 70/7460-1K). It is also important that towers do not have ground-level lighting around them because these lights can attract birds that then collide with tower guy wires (Longcore et al. 2008). Another option for tower lighting is an audio-visual warning system like OCAS (<http://www.ocasinc.com>). This approach uses radar to detect nearby aircraft, activating marker lights and emitting a verbal warning on aviation band radio. It is essentially a motion detector for tower lighting.

Night hiking and mountain biking

Night hiking and mountain biking have become popular activities in natural areas. The lights used in these activities, especially those used in mountain biking, have become brighter in recent years. For example, full-spectrum LED lights that emit 3,600 lumens (approximately the same as a 200-watt incandescent bulb) are advertised for use by bikers. Activities such as these expose wildlife to unnatural disturbance at night; this affects behaviors both because of the disturbance itself and because of the potential bleaching of eye pigments (“blinding”) from which recovery time can take minutes to hours.

Managers can mitigate the impacts of night hiking and biking by employing various strategies. These include:

1. Restrict the time of month when illuminated nocturnal recreation is allowed to the days before and after the full moon. In this manner animals are allowed the darkest part of the month as a refuge from disturbance.
2. Restrict the total luminous intensity of lights used in these activities.
3. Set curfews for illuminated nocturnal recreation.
4. Restrict nocturnal recreation activities to areas that are already disturbed by night lighting, leaving more remote wildland areas protected from nocturnal disturbance.

Campsite lighting

Although “traditional” camping with firelight and flashlights is certainly still a popular activity, more and brighter portable lights are being brought to campsites. Large arrays of lights are readily available and increasingly used by campers. Such lights can degrade the nighttime camping experience for other campers and will have greater impacts on wildlife than a campfire or small personal flashlight. Park managers might consider establishing guidelines for nighttime lighting at campsites, including limits on overall illumination, lighting curfews, and recommendations to use

flashlights instead of area lighting. Lighting restrictions could be established in conjunction with quiet hours, and address portable lanterns and recreational vehicle lights. In especially dark areas, managers could recommend the use of red filters on flashlights. Such actions should be paired with minimizing lighting from the existing infrastructure (e.g., converting lights on bathrooms to low-intensity red lamps).

Off-road vehicles

Deserts and beaches often accommodate vehicular recreation. Vehicles commonly have 1,000–1,500 lumens of forward-facing light, and because this is concentrated in a fairly narrow cone, the light intensity can be very high, with low-beam headlights exceeding 4,000 candela on axis (candela is a unit measuring the brightness of a light emitted in a particular direction). For wildlife along the axis of the headlight, the intensity of a directional headlight is equivalent to an unrestricted 100,000-lumen light source (Schoettle et al. 2004). This disruption can be an intermittent impact or, in some situations, a chronic one. For example, vehicles on a beach will often park with the headlights kept on, in which case multiple headlights will be directed into the shoreline environment and have the effect of a much larger number of streetlights due to their concentrated and directed nature. The most effective mitigation would be to prohibit vehicles from these environments during sensitive times for wildlife. Additional mitigations may include restricting headlights to when the vehicle is moving or requiring low beams only.

Monuments

Parks must consider the need to preserve natural and cultural resources when making decisions related to lighting cultural monuments. For example, the Washington Monument is bathed in white light and is known to attract and kill migratory birds (Overing 1938). Because the Washington Monument has been illuminated at night since the 1930s and is so powerfully symbolic of Washington, D.C., it is not feasible to propose elimination of lighting altogether. Limitation on the hours of illumination is probably the best management action in such situations. Lighting for monuments should be designed to illuminate the monument only, and with the lowest intensity possible. Bright lighting that might have been required to accommodate photography in the past is no longer needed with current digital imaging technology.

Lighting schemes at monuments could also play a role in pest management. At the Lincoln Memorial, the lights are turned on at twilight when midges and gnats fly over from the Potomac River and onto the Memorial. This in turn attracts many spiders that weave webs on the monument and require extensive and frequent cleaning (C. Moore, pers. comm.). It might be possible to turn the lights on slightly later, after the crepuscular period, or to change the spectrum of light used to eliminate short blue and ultraviolet wavelengths. In such a manner the lighting scheme then becomes part of an Integrated Pest Management program.

Light-assisted fishing

Offshore lighting poses threats both to aquatic and terrestrial ecosystems. Light has a long history of use as a method to attract fishes for capture. In artisanal fisheries, dim lamps may be used on small human-powered boats. Current industrial-scale fisheries, however, use extremely bright lights

(equivalent to 30,000 watts incandescent) to attract squid and other fishes. Even boats that do not use lights to attract their catch operate during the night and are highly illuminated. Illumination in this manner affects behavior of fishes (Nightingale et al. 2006) and other aquatic organisms (Forsythe et al. 2004). Lighting is also implicated in the mortality of seabirds in fisheries (Dick and Donaldson 1978, Carter et al. 2000). Spillover light on seabird nesting colonies has the potential to increase predation on vulnerable species (Keitt et al. 2004). Park managers should take action to reduce fishing activity with disruptive lighting near sensitive island habitats and in marine protected areas. A range of options is available to do so, including outright bans, limiting light-assisted fishing by phase of the moon (to dates around the full moon), and limiting total luminance allowed in protected waters.

Security lighting

Managers are often faced with pressure to install security lighting in hopes of decreasing illegal activity. The evidence that increased illumination reduces crime is unclear at best (Tien et al. 1977, Sherman et al. 1997), and dimming or shutting off lights may in fact reduce crime (Steinbach et al. 2015). Some schools use a “dark campus” approach, wherein all lights are extinguished at a certain hour. Lights seen after this time are then quickly recognized as indicative of unauthorized activity (Mizon 2012). Park managers should think very carefully about installation of any dusk-to-dawn security lighting. It has very little chance of being effective if staff members are not on site to observe activity. Complete darkness at night for areas in parks and protected areas that are off-limits and unoccupied should be considered in consultation with law enforcement.

Bridges

Bridges can introduce artificial lighting into natural areas through roadway lighting for safety or through architectural lighting. Both of these have the potential to disrupt natural habitats. For example, harbor seals used the lights on the Puntledge Bridge in British Columbia to form a “feeding line” and intercept outmigrating juvenile salmonid smolts (Yurk and Trites 2000). Extinguishing these lights led to a decrease in salmon mortality. Other studies document increased predation on fishes under illuminated bridges and docks (Nightingale et al. 2006). For bridges with tall structures, illumination of these towers may result in attraction of migratory birds. Such lighting should be avoided to the extent possible, such that obstruction lighting is limited to red flashing lights (if lighting is required by the FAA) and any roadway lighting is carefully directed onto the roadway with little or no spillover into the river. Furthermore, use of yellow light is preferable under most circumstances to minimize the attraction of insects, although selection of yellow lights alone will not eliminate the effects of lighting on foraging behavior of mammals (Bird et al. 2004). Other considerations with bridges include the synergistic effects of lighting and polarization that misleads insects and may even result in bridges being dispersal barriers along rivers (Horváth et al. 2009, Málnás et al. 2011).

Roadway lighting

Roadway lighting is a major source of outdoor illumination and contributes significantly to sky glow. In a study of lighting in Tucson, Arizona, roadway lighting accounted for 12% of upward directed lighting, following only commercial lights (36%) and sports fields (32%) as a proportion of total

uplight (Luginbuhl et al. 2009). To maintain natural illumination conditions inside parks, managers must work with communities outside park boundaries to address these sources. Inside park boundaries, managers must make the decision whether roadway lighting is necessary in the first place, and if so, what characteristics it should have. To minimize impacts on wildlife, roadway lighting should be avoided to the extent possible, and where used should only be designed for the required intensity. The recommended lighting for a local road with low pedestrian conflict in the United States is 3–4 lux (ANSI/IES RP-8-14), which is more than 30 times brighter than the full moon's maximum intensity, so no roadway lighting is ecologically trivial. Recommended illumination for most roadways ranges from 6–15 lux (ANSI/IES RP-8-14).

One issue with reducing illumination for roadways is a concern that any reduction will increase traffic collisions. Studies of changes to roadway lighting in England and Wales, however, found no significant effect on number of traffic collisions from part-night lighting, switching off roadway lighting entirely, or changing the spectrum of roadway lighting (Steinbach et al. 2015).

Where light is essential, fixtures should be full cutoff and shielded to minimize glare from any non-road site, especially in areas with known sensitive species. The best overall choice for spectrum is probably yellow (e.g., low-pressure sodium or yellow/amber LED), but technical considerations may lead to use of a broader spectrum (e.g., high-pressure sodium). Yellow/amber LED streetlight fixtures are commercially available in response to demand for lighting with minimal impacts on bats (e.g., Innolumis bat lamp from the Netherlands) and other wildlife (e.g., Star Friendly® lights, C&W Energy Solutions).

Other alternatives are available to further reduce the impacts of street lighting. Embedded roadway lighting (**Figure 27**) has been investigated in Florida as a way to minimize impacts on nesting sea turtles (Bertolotti and Salmon 2005). Such lights may be useful in locations where snow plowing is not necessary. Another alternative is the use of dynamic lighting systems that decrease illumination based on the time of day or traffic volume so that lights are extinguished by a certain time at night or at a percentage of peak traffic (Collins et al. 2002).

Interested park managers can consult reviews on the impacts of light from street lighting systems, which recommend against full-spectrum lamps because of ecological, physiological, and dark-sky impacts (Falchi et al. 2011, Bierman 2012).

Vehicles along roads can cause the type of periodic changes in lighting levels that can affect animal behavior (Baker and Richardson 2006) and influence views of the night sky (Luginbuhl et al. 2009). Birds, especially migratory species and seabirds, can be attracted to vehicle headlights (Gauthreaux and Belser 2006). Although additional research on this topic would be welcome, managers can mitigate impacts from headlights by providing shielding of sensitive receptors using a range of physical barriers, including berms, dense shrubs, or even walls in particularly sensitive areas.

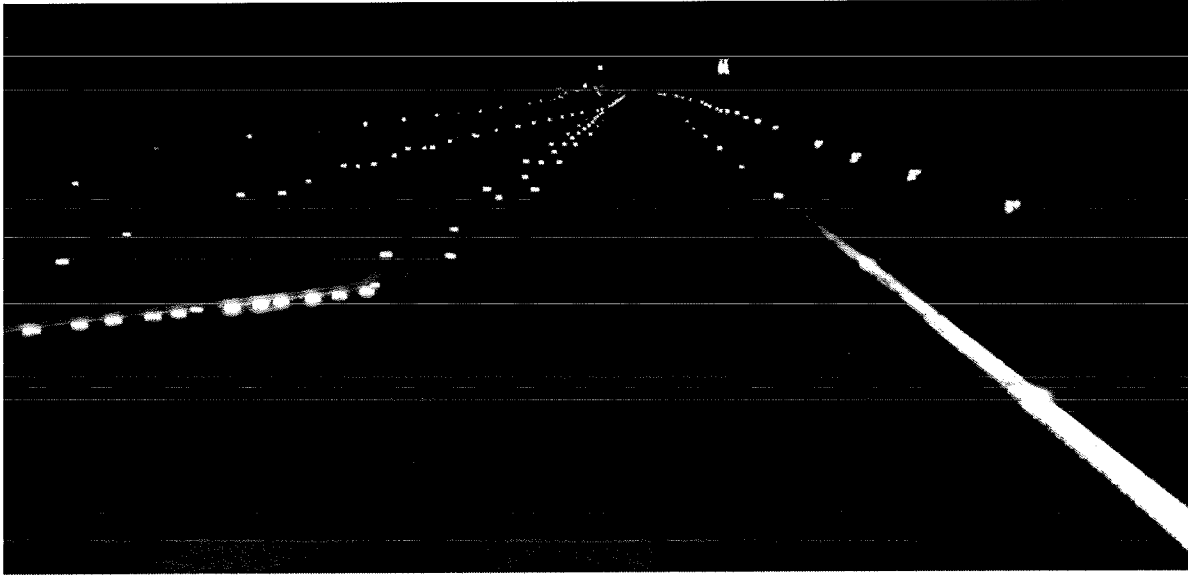


Figure 27. Embedded roadway lighting. These LED lights installed in the pavement are not visible to sea turtles nesting on the adjacent beach and are well received by motorists and pedestrians (Bertolotti and Salmon 2005). Photograph courtesy of Michael Salmon.

Energy production installations

Efforts to increase domestic energy production have resulted in pressure to explore and extract fossil fuels and develop industrial-scale facilities for wind and solar energy both on land and water. Energy production facilities have the potential to affect natural resources on park properties that may be found intermixed with other public and private lands approved for such activities. The direct impacts of such activities are of great conservation concern, but are not discussed here. In the event that such facilities are evaluated in the environmental review process, the following recommendations could be made to minimize the impacts of artificial night lighting.

Wind energy installations are generally illuminated with red flashing lights at the corners of arrays of turbines. Not all turbines have obstruction lighting. Researchers documenting mortality of animals (both bats and birds) at wind turbines have concluded that these flashing lights do not attract birds, but that constant illumination of ancillary structures on the ground is associated with increased bird mortality at nearby turbines (Kerlinger 2004, Kerlinger et al. 2010). Wind turbines currently are estimated to kill on the order of 100,000 (Kerlinger et al. 2011) and 573,000 (Smallwood 2013) birds per year, with this number likely to grow 30-fold in the next 20 years to meet federal goals for renewable energy. Ensuring that lighting is only red flashing with no steady-burning lights on any accessory structures would reduce mortality of nocturnal migrant birds, but would not mitigate the significant bat mortality that is associated with wind turbines (Kunz et al. 2007, Smallwood 2013).

Solar power plants are proposed and being built in open desert areas near parks and protected natural lands. Such facilities should not require dusk-to-dawn night lighting. If security lighting is desired, the recommendation should be made that it be fully shielded, low intensity, and on a motion detector.

Oil and natural gas facilities are often brightly illuminated at night. This light can have adverse consequences for any habitat in which it is found. For example, offshore oil platforms attract seabirds, usually to their detriment (Wiese et al. 2001, Montevecchi 2006). Terrestrial oil and gas facilities are often the only sources of light in remote open spaces. Parks can work with existing facilities to retrofit lights. For marine facilities, some initially positive data have been collected suggesting that using a green light on an offshore platform reduces the number of birds that are attracted to it (van de Laar 2007, Poot et al. 2008). By retrofitting the platform from white lights to green lights, Dutch researchers documented a reduction in the number of birds observed circling a platform (van de Laar 2007). The cause of this reduction could have been the wavelength of light used, or an overall decrease in lighting intensity that was a byproduct of the lighting change. The research shows that decreasing illumination and restricting the spectrum of light is a promising approach to reducing impacts to biological resources while still maintaining safe operations.

Indoor lighting

Although outdoor lighting is usually the focus of efforts to reduce impacts of night lighting on wildlife, indoor lighting should be considered as well. Indoor lighting may contribute substantially to ecological light pollution. In the extreme example of all-glass structures, greenhouses in Germany attract insects and migratory birds (Abt and Schultz 1995, Kolligs 2000). Furthermore, office buildings in urban cores can contribute as much to sky glow as billboards or roadway lighting (Oba et al. 2005). In darker environments, even the lights from a residence may have some effect on local wildlife behavior and degrade the experience of visitors in adjacent natural areas. Managers can be aware of these issues and seek to shield interior lights through use of curtains. This also gives an additional reason to cluster developments within parks. For urban areas and office buildings, guidelines are available to minimize the effects on birds, including through steps to reduce interior illumination (New York City Audubon Society 2007).

Lighthouses

The fatal attraction of birds to lighthouses has been observed for well over a century (Dutcher 1884, Miller 1897, Hansen 1954). In the United States, mortality of birds is more commonly reported on the East Coast than on the West Coast (Allen 1880, Merriam 1885), although mortality has been recorded on the West Coast as well (Squires and Hanson 1918). There has been some conflicting research on lighting color and flashing since the early 1900s (see review in Gauthreaux and Belser 2006), but the view has solidified that mortality can be decreased through the use of a flashing rather than constant light (Baldwin 1965, Jones and Francis 2003, Gauthreaux and Belser 2006). It is important that the light itself flashes, extinguishing completely between flashes, rather than the flashing effect being created by a rotating beam that remains illuminated. Reduction in lighting intensity also reduces bird mortality (Jones and Francis 2003).

Billboards

Billboards and other signage can affect wildlife behavior when illuminated. For example, light from a single billboard was sufficient to change the concealment behavior of juvenile salmon in a stream (Contor and Griffith 1995). While the significance of such behavioral changes is unknown, illumination of billboards and other signs should be controlled to minimize cumulative effects of

lighting on wildlife, especially as digital billboards proliferate. Illumination from a typical digital billboard proposed for installation in endangered species habitat in southern California would have caused lighting levels to exceed 10^{-1} lux (equivalent to that of a full moon) up to 1,000 ft (305 m) from the sign, according to the lighting engineers for the applicant (Longcore 2015; the proposal was not approved). Such intense lighting has the potential to influence nearby sensitive resources and contribute to sky glow.

Conclusion

Light pollution within parks and protected lands can have a measurable impact upon the habitat quality of the park, even if the light itself originates outside of the park's administrative boundary. Minimizing ecological impacts requires that land managers adopt an ethic of using only the minimum light necessary for human needs and being cautious when introducing light into or near a natural landscape. This report provides examples of the range of negative consequences that may arise from artificial night lighting. Though not a compendium of information for every species and every environment, it should provide adequate evidence for reasonable management of lighting in natural areas.

Park managers should first inventory their resources and determine if and where sensitive species or habitats exist. This information can then guide the development of the prescription of lighting zones within a park where different levels of lighting are allowed, depending on the uses and experiences desired for those zones. Lighting zones may be designed to minimize wildlife impacts only or also to integrate other aspects of a park experience. The most sensitive zone would have a prohibition on outdoor lighting or impose restrictions that define a narrow range of allowable artificial lighting. Looser restrictions that still provide adequate mitigation would be delineated for developed areas in parks and those with substantial human nighttime activity. In all instances, mitigation should address spectrum, intensity, direction, and duration. When all four aspects are addressed, mitigations can be effective at reducing ecological disruption from artificial night lighting.

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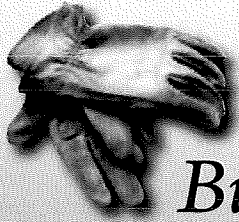
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A Landowner's Guide to Wildlife Friendly Fences:



How to Build Fence with Wildlife in Mind

SECOND EDITION
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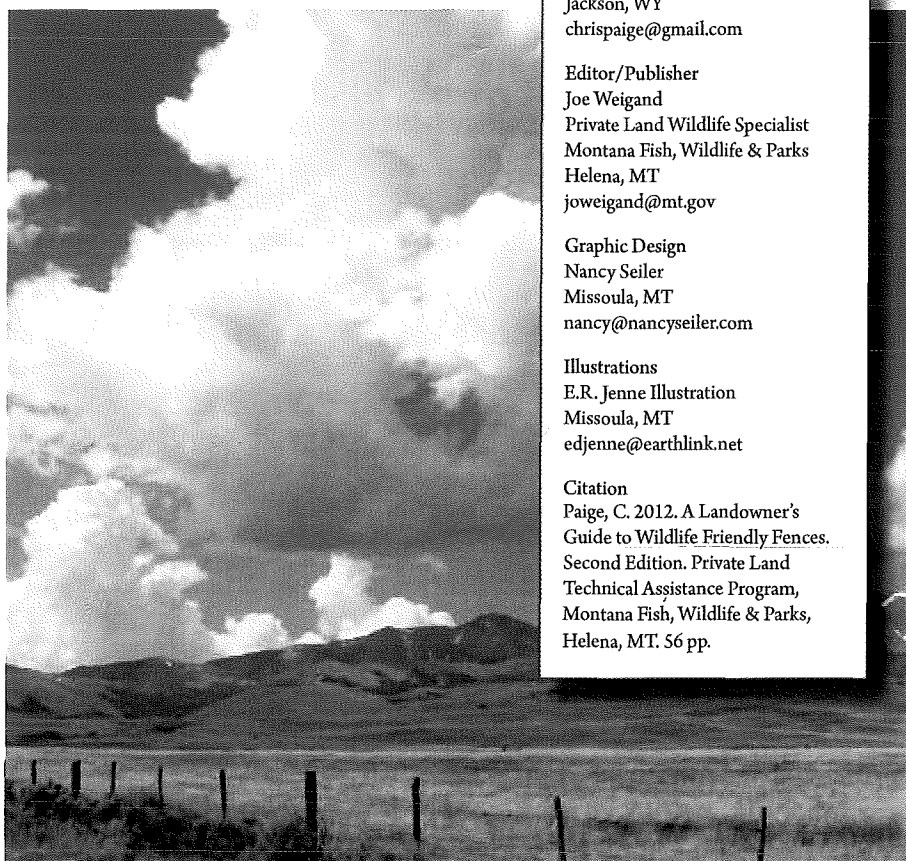
Since the original publication of *A Landowner's Guide to Wildlife Friendly Fences* in 2008, the idea of "building fence with wildlife in mind" has taken off like wildfire across the West. Other states have built on that original publication and produced their own fence manuals, and this author wrote a companion volume for Wyoming, *A Landowner's Guide to Fences and Wildlife*, published by The Wyoming Land Trust.

For this second edition, the material has been revised and updated, benefitting from the creative ideas and practical experience of landowners and resource professionals who have adopted a wildlife friendly approach to their operations. Joe Weigand, Montana Fish, Wildlife & Parks private land wildlife specialist, provided department funding and personal guidance for the project, as well as his extensive expertise from testing various fence solutions with landowners.

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photos, specifications, and experiences with highway right-of-way fence.

Bryce Andrews conducted interviews and wrote many of the profiles detailing landowner and ranch manager experiences. Many other landowners, biologists, and resource professionals in Montana and throughout the U.S. also

contributed their expertise, references, and photographs, considerably adding to the breadth of innovative ideas.

My deep appreciation to Ed Jenne for his wonderful illustrations and to Nancy Seiler for her beautifully creative talent in layout and design. Any errors in this manual are mine alone.

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Wildlife and Fences

Why build wildlife friendly fences?

Fences are essential for controlling livestock and trespass, and countless miles of fence crisscross the West like strands of a spider's web. Fences define and separate ranches and farms, outline property boundaries, enclose pastures and rangelands, and prevent livestock from straying onto highways.

Yet those miles of fence can also create hazards and barriers for wildlife, from big game animals to birds. Fences can block or hinder daily wildlife movements, seasonal migrations, and access to forage and water. Wildlife may avoid areas with too many fences to negotiate. For example, pronghorn choose seasonal ranges with lower fence densities (Sheldon 2005). When animals collide with or become entangled in fences they can be injured or killed, and wildlife damage to fences can be costly and frustrating for landowners.

MANY WILDLIFE FRIENDLY
FENCE DESIGNS ARE EASY AND
LOW-COST, OR SAVE MONEY BY
REDUCING FUTURE FENCE REPAIR.

Not all fences create problems for wild animals. By tailoring fence design and placement, you can reduce wildlife injuries and decrease damage to your fence. Many of these methods are low-cost or can save money in the long-run by reducing the need for future fence repair.

This guide will help you construct and modify fences and crossings that are friendlier to wildlife while still meeting fencing needs. It will also help you with sources for technical assistance and possible cost-share opportunities.

Fence Law in Montana

Fence In or Fence Out?

Most of Montana is classified as open range, which means that by law landowners are responsible for "fencing out" neighboring livestock, and a livestock owner is not liable for trespass or damage if a property is not adequately fenced. This custom has deep roots in Montana's history and ranching traditions. However Montana's open range law applies only to cattle. Bison, sheep, and other livestock must be fenced in (Mont. Code Ann. § 81-4-201).

If the area you live is classified as "closed range," however, the livestock owner is responsible for "fencing in" all livestock. Incorporated cities and towns are classified as closed range. Counties may also create "herd districts" in unincorporated rural areas that are classified as closed range. If you're unsure if your area is open or closed range, contact the Montana Department of Livestock (MDOL; www.liv.mt.gov).

In practice, many livestock operators fence their property and pastures to better manage their livestock and range resources. Where their pastures adjoin federal lands, livestock owners are also responsible for preventing their livestock from illegally trespassing on those lands.

Along railroads, the railroad company must build and maintain fences to keep livestock from wandering onto the tracks. Similarly, the Montana Department of Transportation (MDT) can construct fences along highways to prevent livestock from wandering into the right-of-way.

Legal Fence

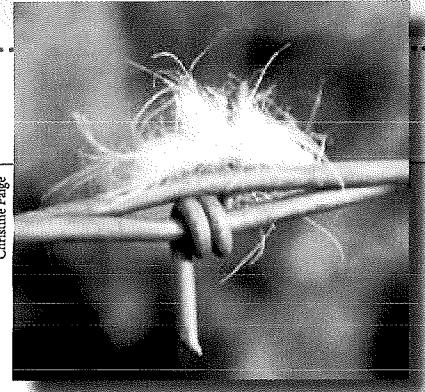
Montana Code defines a legal fence as one of several possible designs (Mont. Code Ann. § 81-4-101). Generally, a legal fence is one constructed well enough to keep out or contain livestock. While the code defines heights for a legal fence, it also stipulates that "all other fences made of barbed wire, which shall be as strong and as well calculated to protect enclosures" as the standards specified are also legal. All "rivers, hedges, mountain ridges and bluffs, or other barriers over or through which it is impossible for stock to pass" are also included as legal fence.

Posting Against Trespass

In Montana, notice against trespass on private land must be placed on a post, structure, or natural object, either by written notice or with at least 50 square inches of fluorescent orange paint. For metal fence posts, the entire post must be painted. Notice must be placed at each outer gate and normal point of access to the property, including both sides of a water body wherever it intersects an outer boundary line (Mont. Code Ann. § 45-6-201).

Other Regulations

Check your local covenants and county and city offices for specific fence regulations. If your property adjoins a state highway, contact MDT regarding options for modifying highway right-of-way fences for wildlife (www.mdt.mt.gov).



Christine Paige

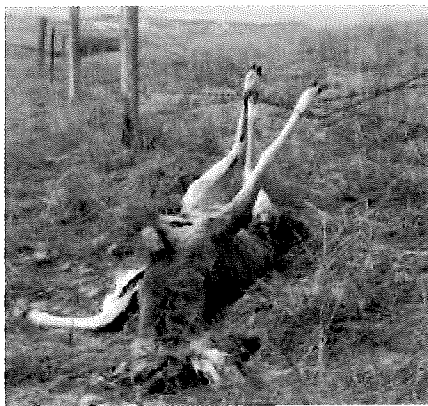


Problem Fences

Deer, elk, moose, bighorn sheep, and pronghorn are all capable of jumping fences, but many common fence designs and situations can snare and injure these and other wildlife.

Wire strands can readily entangle legs, especially if wires are loose or spaced too closely together. Deer, elk, and other wildlife often bear scars from wire barbs. A torn ligament, strained leg, or infection can reduce an animal's chance of survival, and if animals can't pull free at all, they die slowly of trauma and dehydration.

Animals can be blocked by fences that are too high, impermeable, buried in deep snow, or on steep slopes. Young, pregnant, or winter-stressed animals may have a particularly difficult time clearing fences.



Cory Loecker

Some fences, especially woven wire fence, can be a complete barrier to fawns and calves even if adults can still jump over. Separated from their mothers and stranded from the herd, the youngsters often curl up and die of exposure and dehydration. Woven wire can snare and strangle medium-sized animals and livestock if they push their heads through the wire mesh, and may block animals such as bears and bobcats that are too large to slip through.

If woven wire is topped with one or more strands of barbed wire, the fence becomes a complete barrier, especially for fawns, calves, pronghorn and other animals that are incapable or



Colorado Parks and Wildlife

WINTER-STRESSED, PREGNANT AND YOUNG ANIMALS MAY ESPECIALLY HAVE TROUBLE CLEARING FENCES. AN INJURY OR INFECTION FROM TANGLING WITH FENCES CAN REDUCE AN ANIMAL'S CHANCE OF SURVIVAL. IF ANIMALS CAN'T PULL FREE AT ALL, THEY DIE OF TRAUMA AND DEHYDRATION.

unwilling to jump over such a fence. Animals trying to leap a woven wire fence topped by barbed wire are even more likely to tangle a leg between the top barbed wire and the stiff woven wire.

In urban areas, fences topped with barbs or pointed spikes, such as decorative iron fences, can trap or impale leaping deer and other animals.

Large, low-flying birds, too, may collide with fences and break wings, impale themselves on barbs, or tangle in wires. Ducks, geese, cranes, swans, grouse, hawks, and owls are especially vulnerable. Waterfowl fly into fences that run near or across waterways, and hawks and owls may careen into fences when swooping in on prey.



Mark Gocke



Shelia Lamb



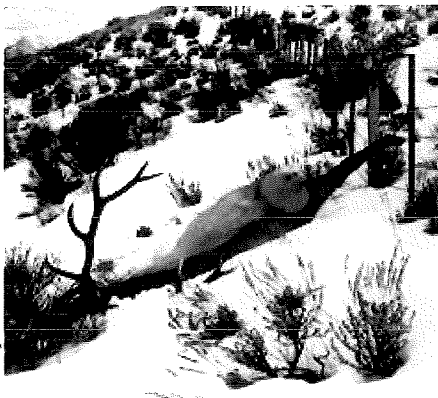
Problem Fences



Jack Jones



Jeremy Roberts, Conservation Media



Tom Campbell

What kinds of fence cause problems for wildlife?

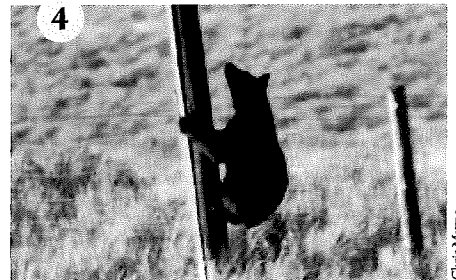
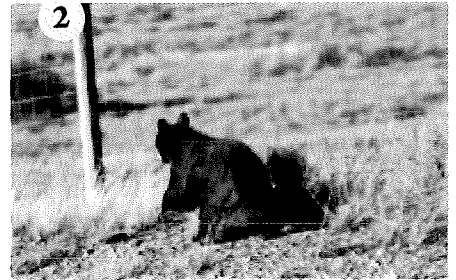
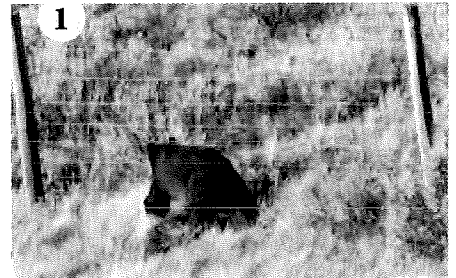
Fences that:

- are too high to jump;
- are too low to crawl under;
- have loose or broken wires;
- have wires spaced too closely together;
- can impale or snag a leaping animal;
- are difficult for running animals or birds to see;
- create a complete barrier;
- create a 3-dimensional obstacle.



Doug Wood

Above: This peregrine falcon died when it collided with a fence while diving on killdeer. Many birds are vulnerable to fence collisions.



Chris Mayne

Above: After crossing a highway, a black bear desperately searches for a way through a woven wire fence, finally climbing a power pole to leap over.

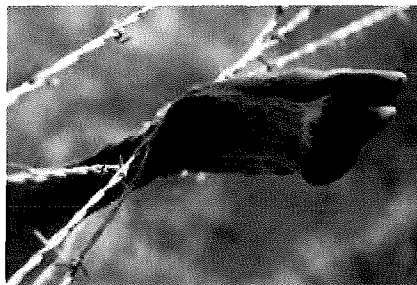


Tom Kroening, Colorado Parks and Wildlife



The Bottom Line: Hard Numbers

Recently, researchers at Utah State University completed a study of wildlife mortality along more than 600 miles of fences in the rangelands of northeastern Utah and northwestern Colorado (Harrington 2005, Harrington and Conover 2006). By repeatedly driving and walking fencelines over two seasons, they tallied the number of mule deer, pronghorn, and elk carcasses they found caught in fences and lying next to fences. They also studied which fence types caused the most problems.



The Jackson Hole Guide

Here are their key findings:

Snared and Entangled

- On average, one ungulate per year was found tangled for every 2.5 miles of fence.
- Most animals (69% of juveniles and 77% of adults) died by getting caught in the top two wires while trying to jump a fence.
- Juveniles are 8 times more likely to die in fences than adults.
- Mortalities peaked during August, when fawns were weaned.
- Woven wire fence topped with a single strand of barbed wire was the most lethal fence type, as it easily snared and tangled legs between the barbed wire and rigid woven wire.
- 70% of all mortalities were on fences higher than 40".



Steve Pimm

TIP:

IF YOU ATTEMPT TO RESCUE A TANGLED AND STRUGGLING ANIMAL, AND YOU CAN SAFELY DO SO, COVER ITS HEAD WITH A CLOTH OR COAT TO HELP CALM IT.



Bryce Andrews

Above: This badly tangled pronghorn was fortunately freed by the photographer, who was able to clip the wires.

Blocked and Stranded

- Where ungulates were found dead next to but not in fences, on average one ungulate per year died for every 1.2 miles of fence.
- 90% of these carcasses found near fences were fawns lying in a curled position – probably separated from their mothers when they could not cross.
- Most of these indirect mortalities were found next to woven wire fences.



Randy Garza



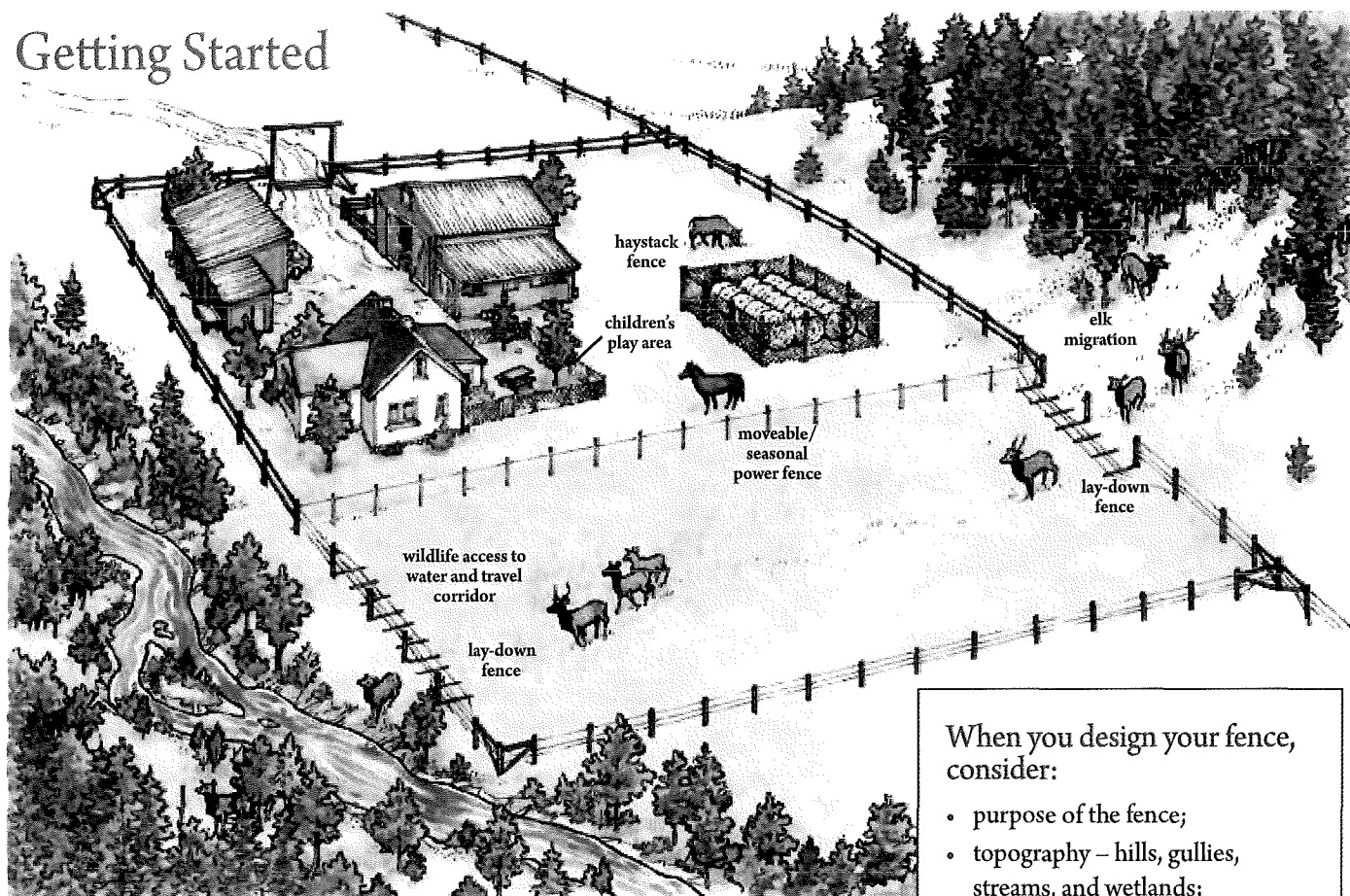
Tim Stevens

Antlered animals can become fatally tangled in poly rope fence and loose barbed wire. Maintaining fence tension and using high-tensile wire for electric fences can help prevent such losses.



Wildlife Friendly Fences

Getting Started



The best situation for wildlife is open habitat with no fences at all. Wherever possible, remove obsolete fences that are no longer needed.

Where you need to fence, less fence is better. Established fences can be modified to allow easier passage, and new fence can be designed with wildlife in mind.

To get started, consider your needs and create a plan. You can tailor any of the designs in this guide to your specific needs.

First consider these questions:

1. What is the purpose of the fence?
Do you need to mark a boundary? Deter trespass? Enclose or exclude livestock? If your fence is for livestock, what kind, in what seasons, and for how long?

Your purpose should determine your fence design and placement.

2. What is the topography?
Are you fencing on hills, in rocky country where posts cannot be driven, or near or across streams or wetlands?
Design your fence to avoid creating traps for wildlife.

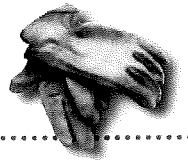
3. Which wildlife species are in your area?
Build fence or crossings that both young and adult animals can negotiate.

When you design your fence, consider:

- purpose of the fence;
- topography – hills, gullies, streams, and wetlands;
- species of wildlife present;
- daily or seasonal wildlife movements in the area;
- presence of water, food, and cover for wildlife;
- presence of young animals.

4. What are the daily or seasonal wildlife movements in the area?
Do animals calve or nest nearby? Does wildlife migrate through to winter or breeding areas?
Allow movement and access through natural corridors and habitats.

MOST FENCES CAN BE DESIGNED OR MODIFIED TO ALLOW EASIER AND SAFER PASSAGE FOR WILDLIFE.



Fence and Crossing Placement

Placement of fences is just as important as the type of fence used.

Fences need not restrict wildlife movement everywhere on your property. Wherever possible, design your fence to provide wildlife free travel to important habitats and corridors, as well as access to water. Wetlands and riparian habitats are especially important for all wildlife.

Watch for daily and seasonal wildlife movement patterns and look for trails. Use impenetrable, special-purpose fence only in specific areas where it is critical, such as calving or lambing pastures, haystacks, gardens, orchards, children's play areas, or kennels.

Design property boundary fence so wildlife can easily cross, or with gaps or lay-down sections for wildlife passage whenever and wherever livestock are not present.

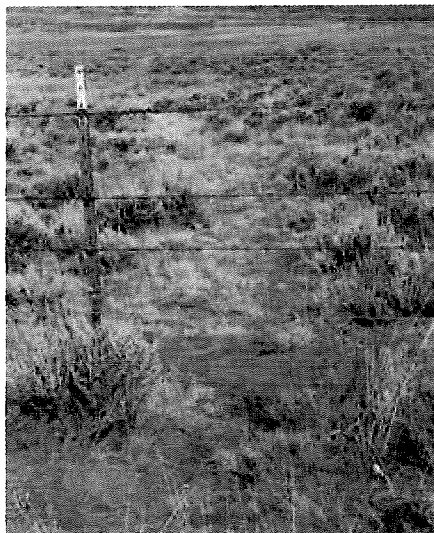
Work with your land's topography. Swales, gullies, ridges, and stream corridors can funnel wildlife through an area. Keep these open to allow wildlife passage and avoid topography traps.

A fence of any height is more difficult to cross when placed across a steep slope or next to a deep ditch. As ground slope increases, the height



Christine Paige

Tailor your fences to specific needs and allow wildlife access to water, important habitats, and travel corridors.



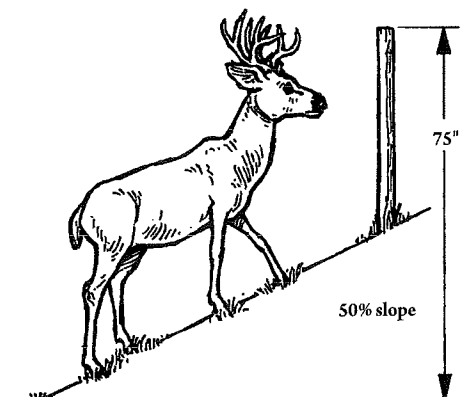
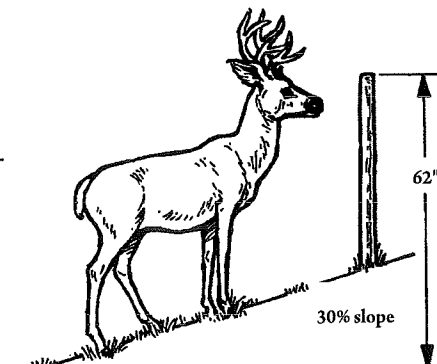
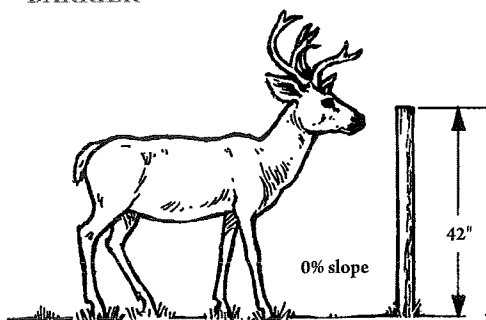
Christine Paige

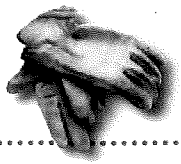
Good Fence Placement Tips

- Look for wildlife trails and watch for seasonal patterns.
- Provide wildlife access to riparian habitats, water holes, and other high quality habitats.
- Provide passage along swales, gullies, ridges, and stream corridors.
- Use the appropriate fence design for each activity.
- On slopes and in natural travel corridors, plan for wildlife crossings.

effective fence height to 48.6"; a slope of 30% increases effective height to 62"; and on a 50% slope animals encounter an obstacle 75" high. **Fences on steep slopes become nearly impossible for animals to jump over without injury.**

SLOPE INCREASES BARRIER





An Ideal Fence

A fence that is friendly to wildlife should:

- Allow animals to jump over and crawl under easily without injury;
- Be highly visible for both ungulates and birds.

You can combine or tailor many of the ideas presented in this guide to your specific situation.

The top wire or rail should be low enough for adult animals to jump over, preferably 40" or less, and no more than 42" high. The distance between the top two wires should be no less than 12" apart. Deer and elk easily tangle their back legs if the top wires are closer together.

The bottom wire or rail should be high enough for adult pronghorn and young wild ungulates to crawl under. The bottom wire should be a minimum of 16" from the ground and preferably at least 18." Take advantage of small dips, swales, and gullies to provide a slightly larger gap below the fence and allow animals to pass under easily. Many cattle ranchers have found that although a small calf may slip under the higher bottom wire, it can also easily slip back again to its mom and not be stranded on the wrong side of the fence.

IDEAL WILDLIFE FRIENDLY FENCE

ALTHOUGH CALVES MAY SLIP UNDER A HIGHER BOTTOM WIRE, THEY CAN ALSO SLIP BACK AGAIN TO MOM AND NOT BE STRANDED.

Increasing visibility using a top rail, high-visibility poly-wire, flagging, or other markers can help ungulates and birds better avoid or navigate fences. Using smooth wire – such as barbless twisted wire – for the top and bottom strands will prevent snagging and injuries.

Use electric tape or braid only for temporary applications. It should be removed or lowered to the ground when livestock are not present.

In some situations, fence stays can help maintain distance between strands,

prevent sagging, and reduce the chance of entanglement. However, wire stays are easily bent over, collapsing the fence and creating a three-dimensional hazard, and need to be regularly maintained. An alternative is a stiff plastic or composite stay or fiberglass post that flexes but maintains its shape.

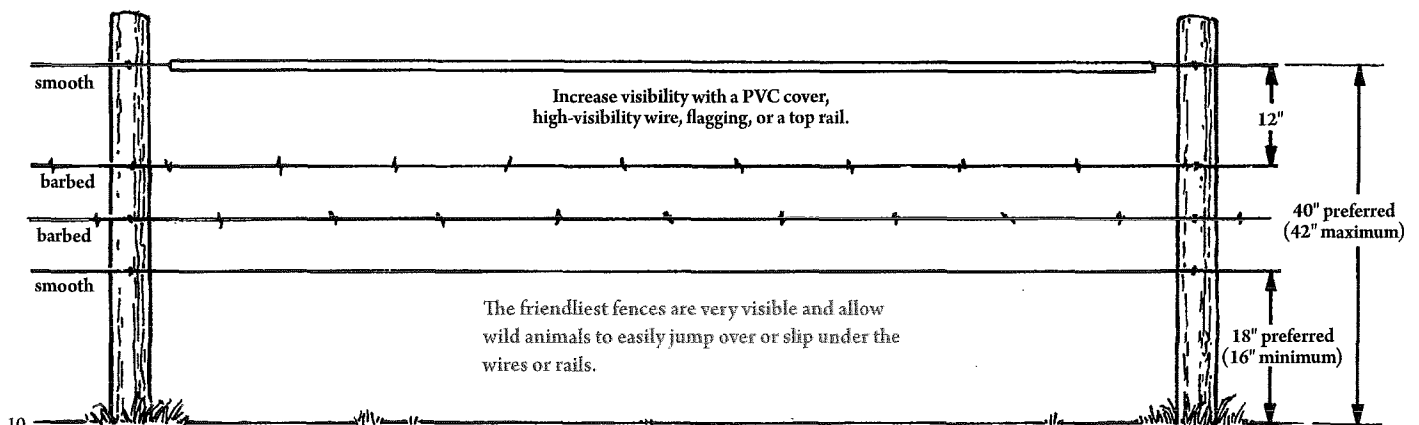
In wildlife migration areas, drop-down fence, lay-down fence, or other crossings can be incorporated into fence sections for seasonal wildlife passage. **Good husbandry practices go hand-in-hand with wildlife friendlier fences. Livestock that have good forage and the security and companionship they want are much less likely to test or challenge fences.**

The Wildlife Friendly Fence: A Livestock/Wildlife Compromise

These standards will control cattle in most situations and allow for easier wildlife passage.

Fences should have top wires low enough for adult animals to jump, bottom wires high enough for wildlife to crawl under, and minimize the chance of tangling. We recommend:

- A top wire or rail preferably no more than 40" and a maximum of 42" above the ground;
- At least 12" between the top two wires;
- A bottom wire or rail at least 16" and preferably 18" above the ground;
- Smooth wire or rail for the top, smooth wire on bottom;
- Preferably, no vertical stays. If used, consider stiff plastic or composite stays, or regularly maintain wire stays that are easily bent;
- Posts at 16.5-foot intervals;
- Gates, drop-downs, or other passages where wildlife concentrate and cross.





Christine Paige



Jay Kolbe

Visibility

Running animals and low-flying birds may not see a wire fence clearly against the landscape. Making a fence highly visible prevents collisions, and can help animals judge the height of a fence for jumping.

One solution is a top rail. A rounded rail is preferable as it sheds snow more easily – heavy snow buildup can sometimes deter elk and deer from crossing. For wire fences, an inexpensive modification is to slip sections of small-diameter PVC pipe over the top strand.

Smooth wire fences, especially high-tensile wire, may be essentially invisible to animals. Depending on the type of fence, these can be made more visible by adding PVC pipe, flagging, fence markers, or highly-visible polywire or polytape on the top strand. Twisted barbless cable is more visible than a single wire strand, and high-visibility wire is available in many

forms – tape, braid and polymer-coated wire – many of which can be electrified if needed. White wire is the most visible in summer, but black and white wire or tape makes the fence visibly obvious against both summer vegetation and snow.

High visibility helps wildlife negotiate fences. It is especially important in grasslands and near creeks and wetlands to protect low-flying birds, such as grouse, owls, and swans. PVC pipe, flagging, or black and white wire or tape all help wildlife see fences.



Montana Fish, Wildlife & Parks



Friendly Designs

Fence Flags for Grouse and Other Birds

Fence flags or markers dramatically increase visibility of wire fences for wildlife, especially birds, and help animals avoid and negotiate fences.

RESEARCH ON SAGE-GROUSE IN WYOMING, IDAHO, AND MONTANA HAS SHOWN THAT FENCE MARKERS CAN REDUCE FENCE COLLISIONS BY 70% TO MORE THAN 80%.

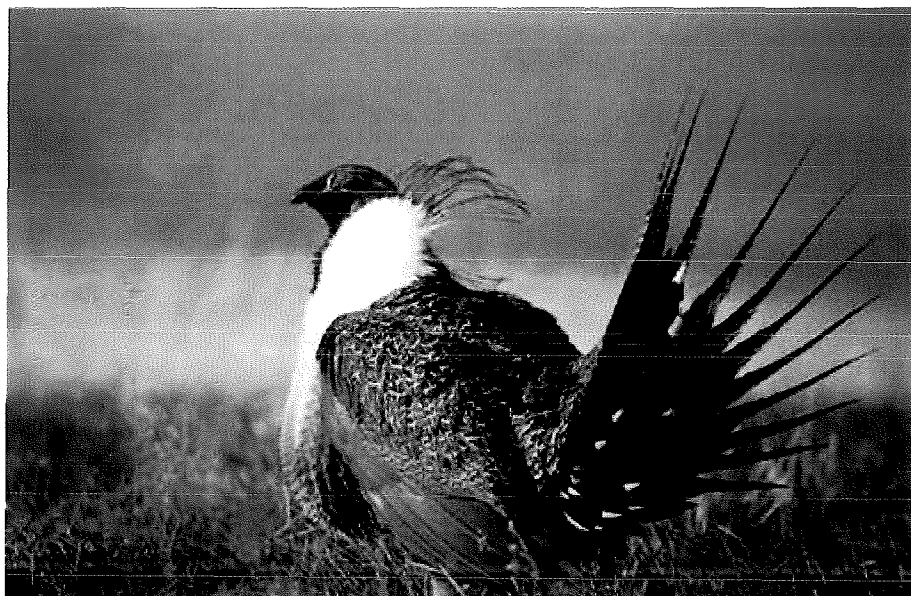
Research on sage-grouse and other prairie grouse has shown that fence collisions are common and widespread, especially near breeding areas.

Grouse fly fast and low into their mating areas (called "leks") just before dawn and, in the dim light, are vulnerable to colliding with nearby fences.

However marking fence for visibility can dramatically reduce collisions by 70% to 83% (Christiansen 2009; Stevens et al. 2012b).



Jeremy Roberts, Conservation Media



Mark Goebel

Markers for Wire Fence

For barbed or woven wire fence:

- Cut several 12' strips of "undersill" or trim strips of white vinyl siding, available at home hardware centers.
 - Cut strips to 3" pieces. Use tin snips for small projects or, with proper ventilation, use a 10" miter saw with a 200-tooth blade to cut up to 16 pieces at a time for larger projects.
 - One 12' siding strip yields 48 pieces.
 - For extra visibility, add reflective tape to both sides of the markers, which increases detection in low light. Or use both black and white markers for visibility against snow and vegetation.
 - Snap pieces onto fence wires – they are held in place between barbs.
- Wyoming Game and Fish has found that, for each 16' section of fence, a minimum of two pieces with reflective tape on the top wire is effective. Or, alternate four pieces of black and white markers on the top wire. Marking a lower or bottom wire will increase visibility for pronghorn and other wildlife.**

For smooth wire fence:

- To keep the vinyl siding markers from sliding, crimp a ferrule, twist a small spring, or tighten a UV-resistant zip-tie (tie-wrap) onto the wire on each side of the marker. Although this adds time to installation, it keeps the markers in place. Crimping the marker itself causes the marker to wear and break.
- An alternative is to make flags from reflective tape that can adhere to the wire. (Note, however, that reflective tape will conduct power on a hot wire.)
- Some commercially made markers available online or in ranch supply outlets may work better on smooth wire.
- Place a minimum of two flags per 16' section of fence on the top wire; or up to four on the top wire and three on the middle or bottom wire.



Not every mile of fence needs to be marked for grouse. Marking is most important where there are high densities of birds: within 1.2 miles of a lek and in wintering areas. Also, sage-grouse are most vulnerable to collisions in open, flat, or rolling country, and in areas with many fences (>1.5 miles of fence per square mile; Stevens et al. 2012a, 2012b).

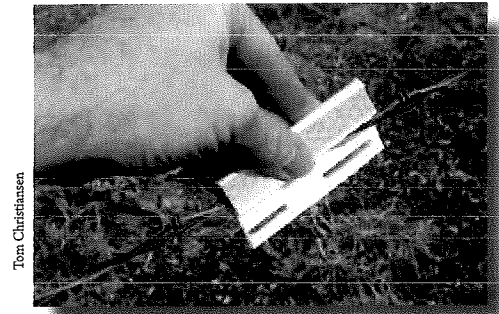
A relatively inexpensive and durable marking technique uses 3" flags cut from vinyl "undersill" or trim siding strips. The undersill siding has a lip that can be snapped onto barbed wire fence, with the barbs keeping the markers from sliding.

As an alternative, commercially produced fence markers can be purchased through a number of retail and mail order outlets.

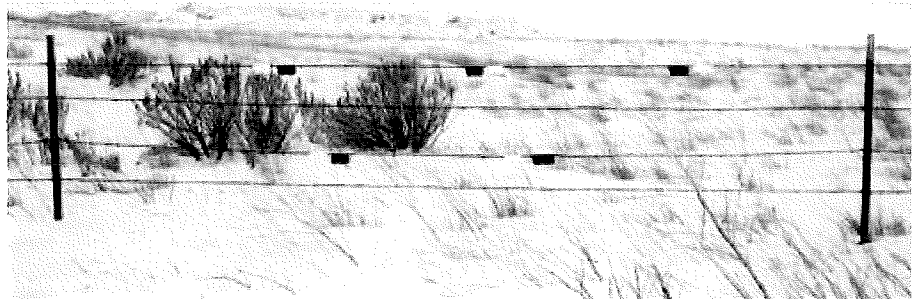
For example, the Firefly Diverter (www.fireflytechproducts.com) has UV-visible reflective tape. Fly Safe (www.flysafellc.com) works on barbed wire. The See-A-Fence marker (www.knifedgedellc.com/seeafence.html) and Fence-flag (www.fenceflag.com) work on smooth wire fence.

While marking the top wire only is effective for grouse, adding markers to lower wires may also help pronghorn and other wildlife that slip under fences.

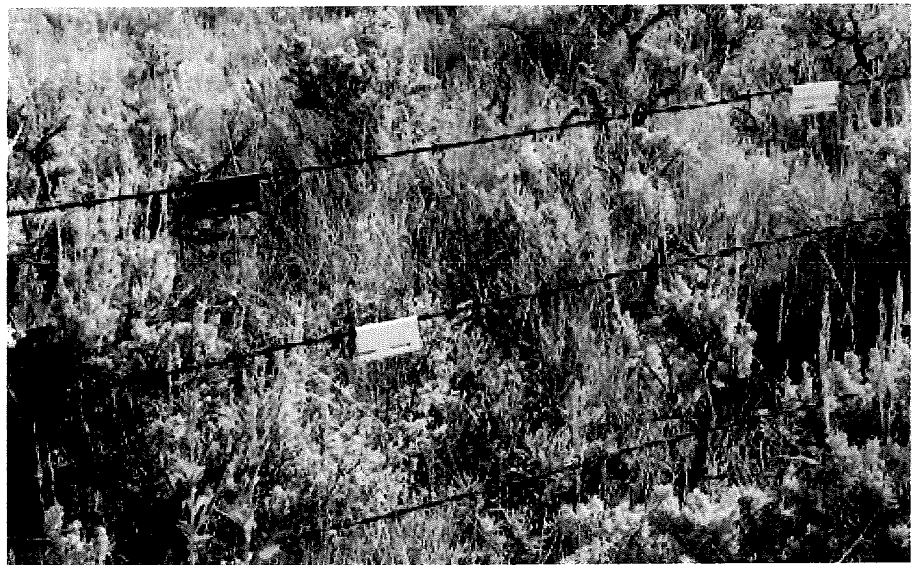
Durable and lightweight fence markers can be cut from strips of vinyl siding trim. The trim strip has a lip that easily snaps onto fence wires.



Tom Christiansen

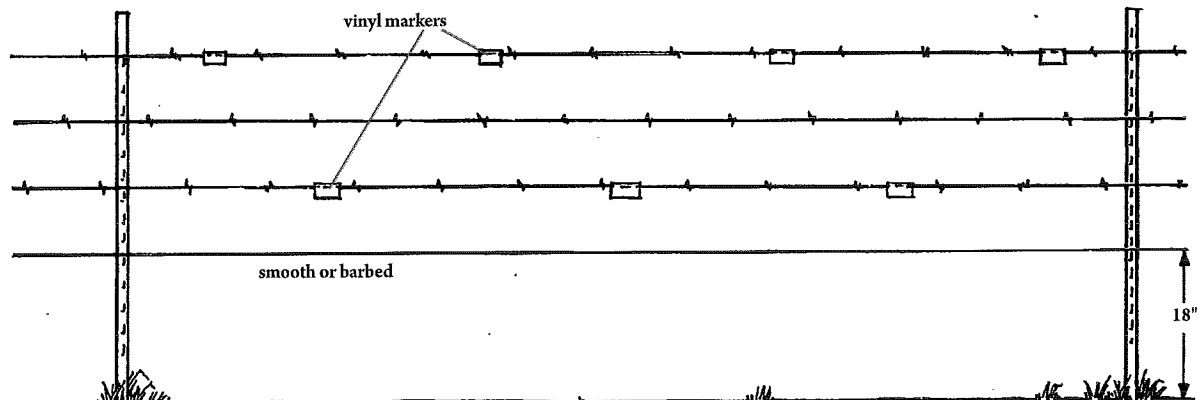


Bruce Waage



Christine Paige

DURABLE MARKERS ON WIRE FENCE





Sites with Low or Seasonal Livestock Use

Not all situations require a 5-strand barbed wire or woven wire fence. Many situations with low or seasonal livestock use can be fenced with a 3-strand smooth wire fence, various types of post and rail fences, or moveable electric fence. Seasonal pastures, cross fences, and horse pastures lend themselves to designs that are much more permeable for wildlife.

3-Strand Smooth Wire Fence

Use 3 strands of smooth (barbless) wire. To increase visibility, use coated wire or barbless twisted cable – the latter can also be more durable than single strand smooth wire. (Note that high-tensile wire should only be used for electrified applications. High-tensile can also be difficult for animals to see, and horses can sometimes be cut by high-tensile wire.)



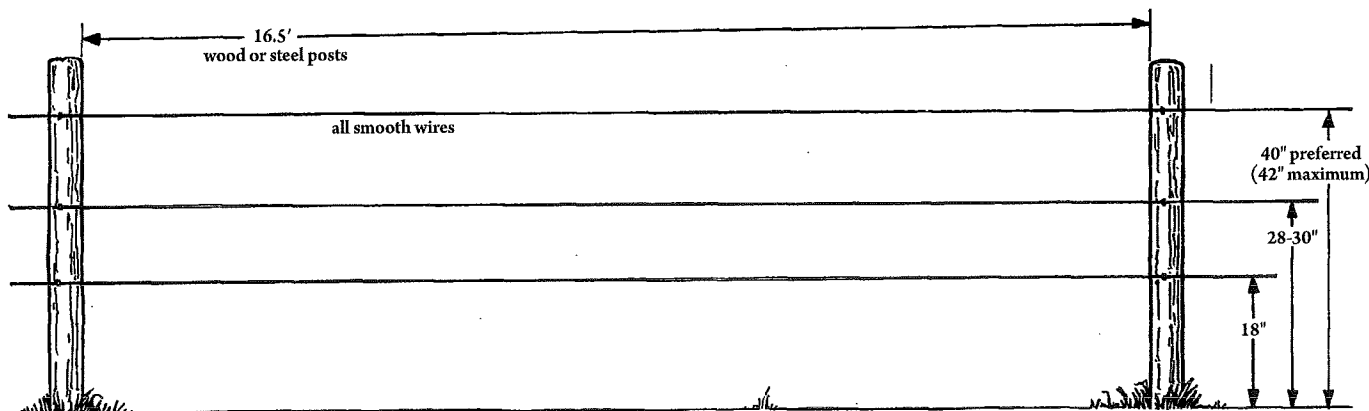
3-Strand Smooth Wire Fence

- Top wire 40" to 42" high.
- Center wire 28" to 30" above the ground; maintain 12" spacing with the top wire.
- Bottom wire 18" above the ground.
- Preferably, no vertical stays.
- Wood or steel posts at 16.5-foot intervals.
- To increase visibility, use coated wire or double twisted smooth wire.



In the center of bighorn sheep winter range, this smooth wire fence replaced old 4- and 5-strand barbed wire fence. The fence is 3-strand smooth wire with a 39" top wire and 16" bottom wire. Bighorn sheep now readily hop over and duck under the fences.

3-STRAND SMOOTH WIRE FENCE



FENCE SOLUTIONS PUT TO THE TEST

Wildlife Friendly Klick Ranch

"When I drove in here yesterday, I parted mountain sheep like Moses did the Red Sea." Dick Klick is talking about the road to his place at Castle Reef, 23 miles west of Augusta, Montana. Dick and his wife, Nancy, winter their horse herd here, and have made some adjustments to deal with the bighorn sheep, deer and elk that share their property.

On their winter place, the Klicks build mostly four-wire fence. The top two wires are barbed, while the bottom two are smooth. The top wire is hung 54" from the ground, and the wires are spaced 10" apart (24"-34"-44"-54" spacing). The fence hangs from six foot steel posts spaced on 17-foot centers.

Although the top wires are very high, the high clearance under the bottom wire allows wildlife to easily slip under and avoid accidental entanglement. When Dick notices an area that is used consistently by wildlife, he often pulls staples on sections of his bottom wire, raising it up to the level of second wire to make crossing even easier. Even modified this way, the fences effectively contain his horses.

In the summer, the Klicks graze their horses at the head of the Gibson Reservoir,



Christine Paige

on a 3,000-acre Forest Service allotment bordering the Bob Marshall Wilderness. Their place is remote, accessible by jet boat or horse depending on the season.

On the doorstep of the Bob Marshall, the Klick's allotment is used extensively by wildlife. In summer and early fall, the horses share the range with a large number of elk. Wherever possible, the Klicks have relied on natural barriers such as cliffs, steep slopes, and box canyons to contain their horses. To keep wildlife from damaging the three miles of fence they've built on the allotment, Dick and Nancy have

experimented extensively with design, location, and wire spacing.

On their summer place, the layout they favor is two barbed wires, the top wire at 48", the bottom wire 8" below that at 40", leaving ample clearance below. "It's 99% good for holding horses," says Dick. "The bull elk jump it, and everything else goes under easily, without even causing a ripple."

Dick stresses the importance of fence visibility in reducing wildlife conflicts.

He finds that fencing through dense trees often results in wildlife damage.

Because of this, he generally leaves a buffer zone between his fence and the tree line in meadows. When forced to go through trees, and if his Forest Service lease allows it, **Dick clears a pathway on either side of the fence to increase its visibility to wildlife.**

Replacing old fence with new, more wildlife friendly designs takes thought and effort, but Dick seems happy with the balance he's struck. The new fences are easier to maintain, and stand up better to wildlife crossings and snow drifts. "I'm getting older," Dick says. "I don't like to see a quarter-mile of fence strewn across the place by wildlife. We must work with animals up here."

— Bryce Andrews



Christine Paige



Seasonal Electric Wire Fence

A flexible electric fence that allows passage for elk and other ungulates can still be effective for livestock, particularly horses trained to electric fence. It can be laid down seasonally to allow free wildlife passage. This fence is useful for keeping livestock out of sensitive habitats or for short-duration grazing where permanent fence isn't desired.

To work properly, this fence needs to flex as elk and other animals pass over it. Install as few rigid post supports as possible, and use the minimum recommended wire tension. Placing the energizer toward the middle of the fence will afford the greatest electrical efficiency.

Seasonal Electric Wire Fence

- Use pre-drilled 72" x 1" heavy fiberglass posts.
- Drive posts 24" into the ground at a 32-foot spacing (a t-post pounder can be used if ground is soft).
- Use treated wooden posts for bracing at ends and center.
- Place a top wire of conductive high-visibility tape, braided wire, or polymer-covered wire no higher than 42" height, electrically charged (medium-tensile 12-gauge plastic-coated wire is satisfactory).
- Place a second grounded strand of high-tensile wire at 30".
- Attach strands to fiberglass posts with wire clips that can be removed when fence is laid down.
- Use insulators for attaching hot top wire to wooden posts; grounded wire can be stapled or clipped directly to wooden posts.
- Use a solar electric energizer (size and placement depends on the run length of fence).
- Hard-wiring is an option when a power source is readily available.



This 2-strand seasonal power fence can be used where livestock are trained to electric fence. Wooden posts brace the ends. The fiberglass posts can be laid down when the fence is not in use.



FENCE SOLUTIONS PUT TO THE TEST

Collaboration in the Blackfoot Valley

"Zero maintenance – it's been amazing," says Juanita Vero of her new stretch of electric fence. Juanita, the fifth-generation owner and manager of the E Bar L guest ranch in Montana's Big Blackfoot Valley, has fixed her share of damaged fence. On the E Bar L, 80 head of horses share 4,000 acres of range with large numbers of deer and elk.

WHEN I ASKED MY 91-YEAR-OLD GRANDFATHER IF THE FENCE PROJECT WAS A SUCCESS, HE QUIPPED, "WE WOULDN'T DO IT IF IT WASN'T GONNA WORK."

— JUANITA VERO

The vast majority of fences on the property are built with three- or four-barbed-wires hung from steel posts. Though these designs worked well on some parts of the ranch, they often failed when built across elk migration corridors. One particularly troublesome stretch ran for a half mile along the edge of an irrigated hay pasture. Elk crossed the fence on their daily circuit between the Blackfoot River and a stand of timber, frequently causing damage. The Veros were ready for an innovative approach to fencing, and they sought the help of Jay Kolbe, Montana Fish, Wildlife & Parks biologist, to help design the project.

Under an agreement to evaluate the design, and splitting costs and labor, FWP and the Veros built a two-wire electrified fence on 1" diameter fiberglass posts spaced

approximately 32' apart. The top wire, hung 48" off the ground, is a high-visibility, plastic-sheathed, conductive wire designed especially for horses. The lower ground wire, hung at 40", is standard 12.5 gauge high-tensile steel.

The new fence works well. "Elk go right through it," Juanita says. "When nobody is putting pressure on them, even the big bulls go under with no problem." It holds their herd of horses well, too, although Juanita remains uncertain whether the fence would adequately contain other types of livestock.

The Veros have experimented successfully on other parts of the ranch.

They use temporary electric fence to divide pastures into smaller units, allowing them to better control the way their herd grazes. Because this polywire fence is a single-strand design, it is highly permeable to wildlife.

Although most fence on the property remains barbed-wire, and the cost of replacing it with electric fence is high enough to be prohibitive, Juanita is upbeat about the potential for future innovation: "The best thing of all is that we have good agency people like Jay to work with, and a history of collaborative conservation in the Blackfoot Valley to build on."

— Bryce Andrews



Juanita Vero



Friendly Designs

Moveable Electric Wire Fence

Moveable electric fence can be used for short-duration grazing, to keep livestock out of sensitive areas such as wetlands, or for other situations where livestock need to be temporarily controlled. This fence works well for livestock that have been previously trained to electric fence.

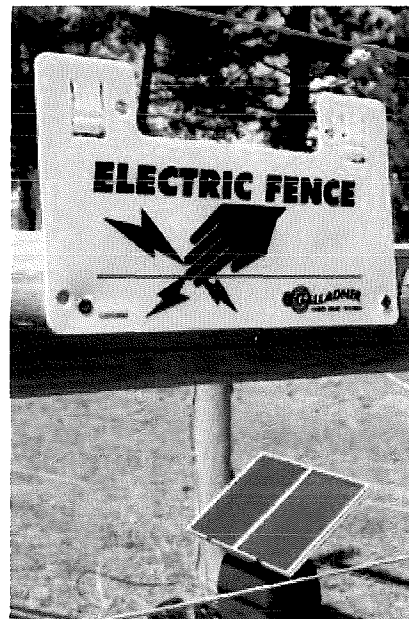
The design can be tailored to your situation, but a simple fence can be constructed using high-visibility tape or "turbo wire" and fiberglass posts or plastic-insulated steel posts. A moveable fence can use either a single hot wire (when there is sufficient moisture for an adequate ground) or two wires, the top one hot and the lower wire grounded. Moveable posts on the market include designs with hooked or pigtail tops for quickly stringing wire, and a tread-in base. These can be rapidly set up and moved as needed.

Moveable Electric Wire Fence

- Use 40" to 42" fiberglass or plastic-insulated steel posts, designed with hooks or loops for wire and tread-in spikes at the base.
- Place one to two strands of high-visibility tape or polymer-covered turbo wire. If using two wires, the top should be hot, the lower wire grounded. Top wire should be no higher than 42"; lower wire no lower than 18".
- Use a solar electric energizer (size and placement depends on the run length of fence).

Tips on Electric Fences

Most electric fence problems are caused by poor grounding. Follow the manufacturer's specifications for grounding the energizer and fence for your fence type and conditions. The number of ground rods needed may vary; a maximum reading of 0.2kv on a volt meter in dry conditions indicates an adequate ground. Wooden and steel fence posts require insulators for attaching hot wires; ground wires can be stapled or clipped on directly. Fiberglass and plastic line posts do not need insulators, but do require special clips for attaching wires. Check the fence regularly to be sure it is charged.



Seth Wilson



Christine Paige

A temporary electric fence can be used to keep livestock out of sensitive areas or to manage pasture use, and is easily negotiated by most wildlife.

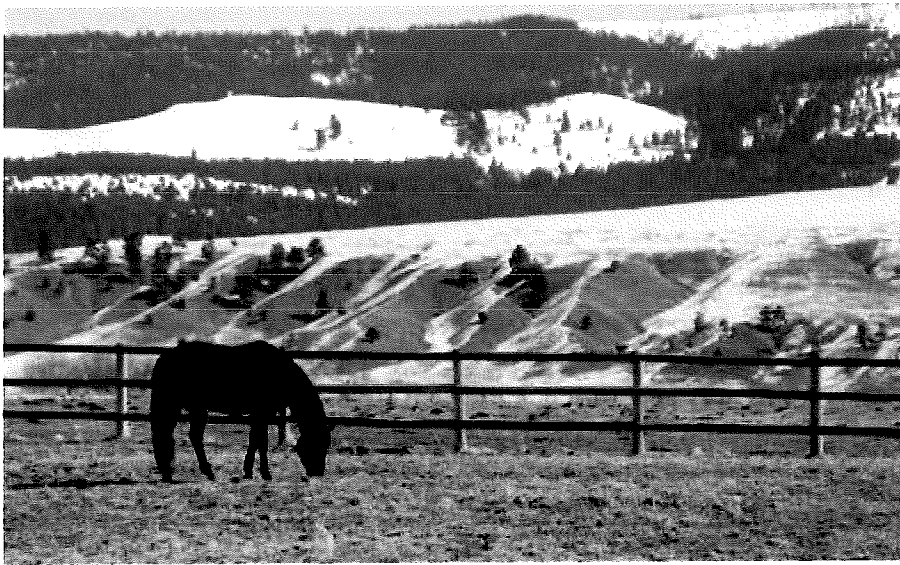


Post and Rail Fence

A post and rail fence is highly visible to wildlife and can be constructed for situations with or without livestock. Rail fences can either use a top rail with wires below, or two to three rails total.

A 2-rail fence is preferable to a 3-rail fence for wildlife. Unless the fence is quite low, use rounded poles for the top rail rather than a square or split-rail to prevent too much snow build-up in winter, which can deter elk and deer. Also, unless the fence

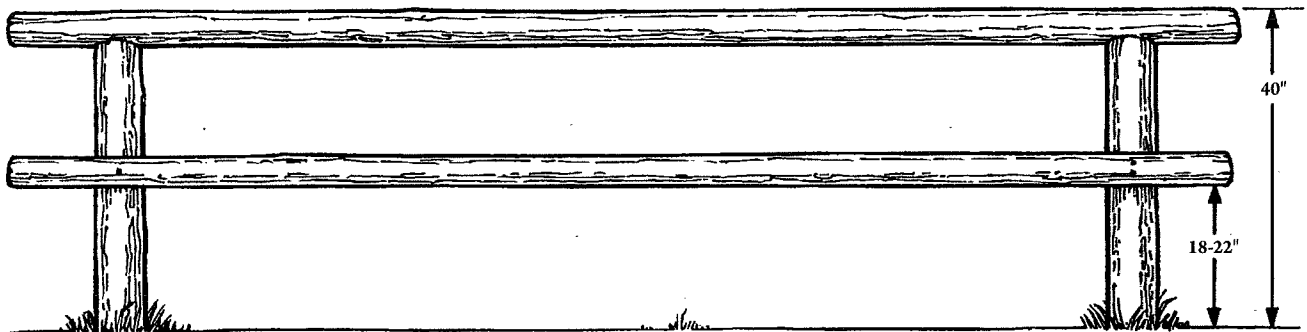
is low enough to be easily jumped over and there is ample clearance underneath, boards or planks are not recommended, as these can create a visual barrier.



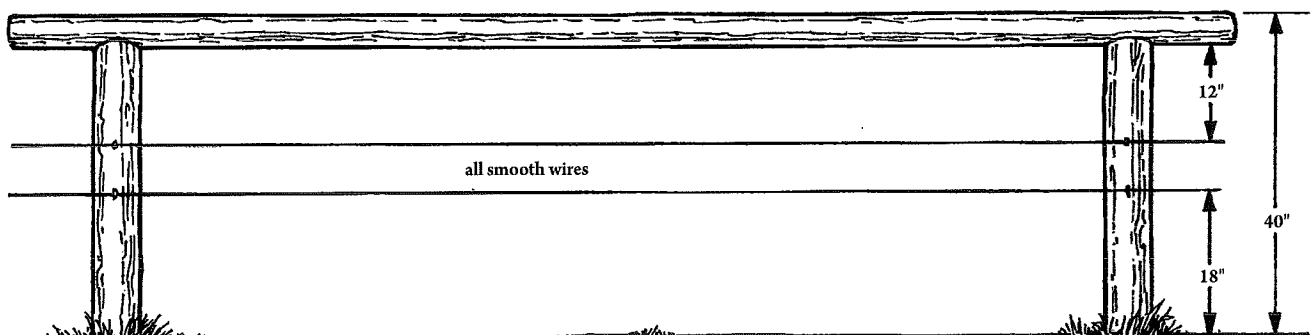
Post and Rail Fence

- Use pressure-treated 6' to 8' posts, spaced 10' to 14' apart.
- Use pressure-treated poles for top rail, placed no more than 40" above the ground. A half-round rail will attach more snugly and require shorter bolts.
- Place smooth lower wires at 18" and 28" above the ground. Second wire should be at least 12" below top rail.
- OR use pressure-treated poles for lower rails, the bottom rail placed with at least 18" clearance from the ground.

POST AND RAIL FENCE



POST AND WIRE FENCE





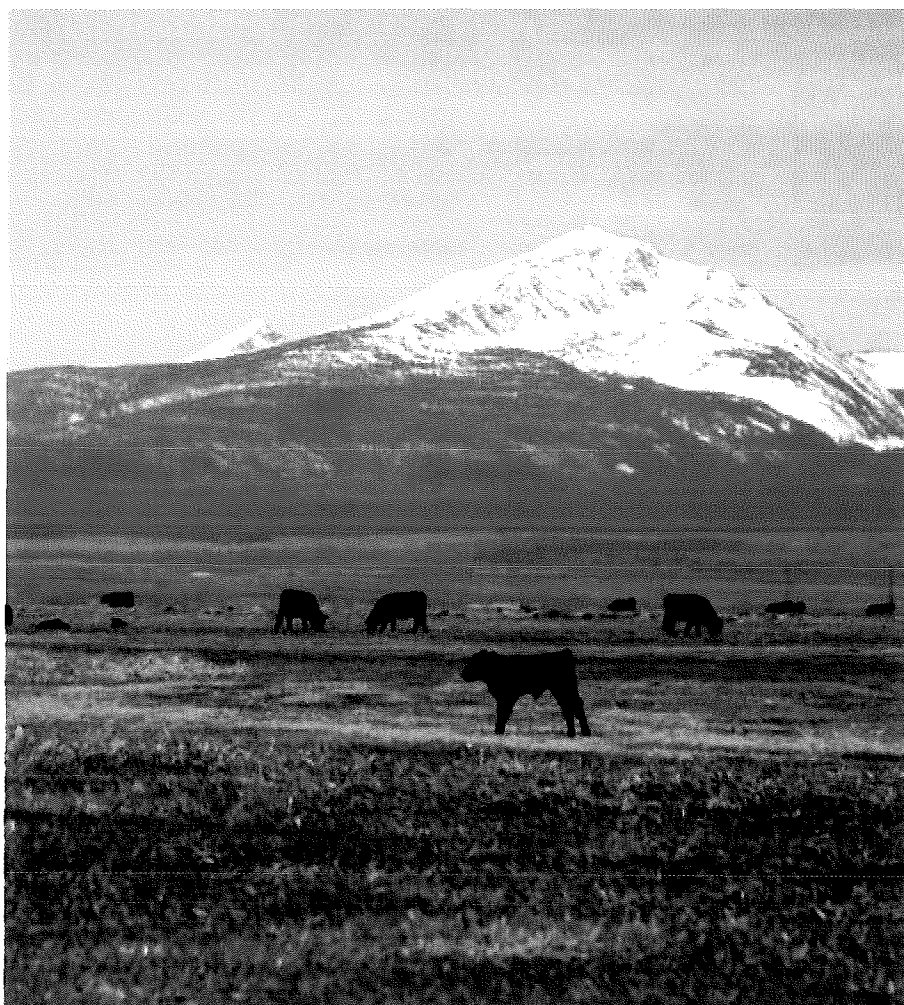
Sites with High or Continuous Livestock Use

Most livestock pastures do not require a 5- to 6-strand barbed wire fence. In many situations, a 3- or 4-strand barbed wire fence, a combination of smooth and barbed wire, or a high-tensile electric fence will work well for livestock control, particularly if the pasture quality inside the fence is as good or better as outside the fence.

Tips for Livestock Fences

Sheep, bison, and cows with calves may require a more impermeable fence for control. If you must use fences with woven wire or more than four wires follow these tips:

- Consider the placement of the fence perimeter carefully, and limit the extent of impermeable fence wherever possible.
- Avoid excluding wildlife from streamsides and water sources, or cutting off migration and travel corridors.
- Keep the fence height to a maximum of 40" to 42" and create periodic crawl-openings for fawns and calves by raising the bottom 18" from the ground, placed where animals typically travel.
- Avoid topping woven wire fences with barbed wire. In any situation, allow 12" between the top wire and the next wire below – whether barbed or woven wire.
- Create seasonal openings using lay-down fence sections or gates to open the fence during months when livestock are not present.



Christine Paige



Christine Paige

Create seasonal openings by leaving a gate open, lowering rails or wires, or using sections of lay-down fence during months when livestock are not present.



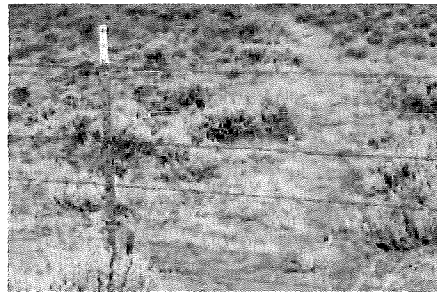
4-Strand Wire Fence for Cattle or Sheep

Woven wire fence, the most commonly-used type of fence on sheep range, is also the most problematic for wildlife. It can block wildlife passage, particularly for fawns, calves, pronghorn, and medium-sized animals unable to jump fences. When combined with barbed wire, it has the highest rate of entanglements for wildlife.

An alternative for sheep and cattle range is a 4-strand barbed wire fence that controls livestock but still allows for passage of pronghorn, deer, moose and elk.

For cattle, use a wire spacing of 18"-22"-28"-40"/42". The top wire should be at 40" to 42" or less. Allow 12" between the top two wires and 18" between the bottom wire and the ground. Use a smooth bottom wire.

Sheep require a low fence that would block most wildlife from crawling beneath the fence. However, a 4-strand fence for sheep can have a top wire no more than 32" high, which is low enough for most wildlife to jump. Allow at least 10" between the top two wires. A lower fence is easier for deer and elk to jump over, and the 10" spacing between top and second wire will usually be adequate. The bottom wire should be smooth wire and at least 10" above the ground.



A bottom smooth wire aids passage for pronghorn and other wildlife.

Combination Smooth and Barbed Wire Fence

In many situations, a combination of smooth wire and barbed wire can effectively contain livestock and allow for easier wildlife passage. Smooth wire can be used for the top and bottom wires and one to two barbed wire strands are used for the center strands. Barbless twisted cable wire or coated wire will increase visibility for wildlife. The top wire should be 40" to 42" high or lower, and the bottom wire at least 18" above the ground to provide wildlife clearance. Allow at least 12" between the top and second wires.

Combination Smooth and Barbed Wire

- Place top smooth wire at 40" to 42" maximum height – barbless twisted cable wire or coated wire is recommended.
- Allow at least 12" between top and second wires.
- Place bottom smooth wire at least 18" from the ground.
- Use barbed wire for center two wires.

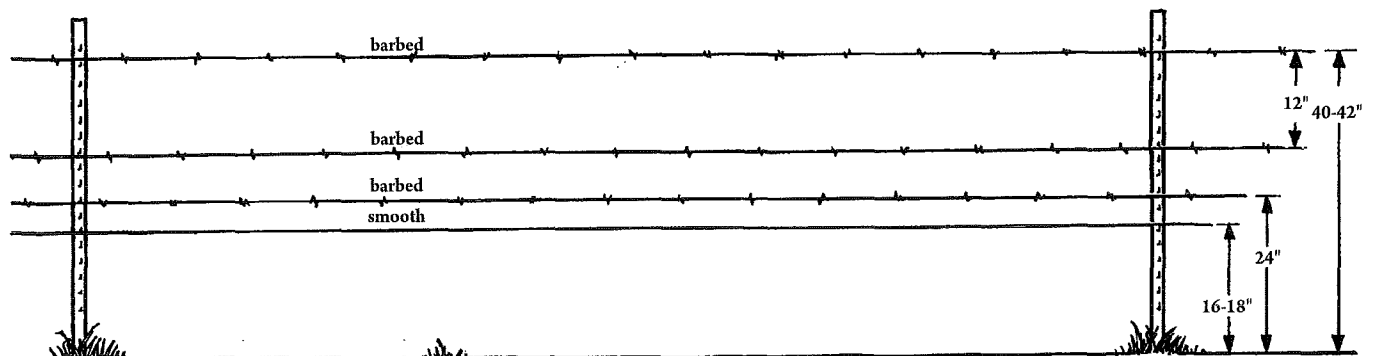
Sheep and Cattle 4-Strand Barbed Wire Fence

(Adapted from Wyoming Game and Fish Dept., 2004)

Recommended Wire Heights Above the Ground

	Cattle	Sheep	Sheep and Cattle
Top wire	40" to 42" barbed	32" barbed	38" barbed
2nd wire	28" barbed	22" barbed	26" barbed
3rd wire	22" barbed	16" barbed	18" barbed
4th wire	16" to 18" smooth	10" min. smooth	10" min. smooth

4-STRAND FENCE WITH BOTTOM SMOOTH WIRE





Wire Suspension Fence

Suspension fences have been used successfully on ranches for decades, and with modern materials they are proving to be durable, long-lasting, and low-maintenance. Wires are suspended across a long run between anchor posts, with fence stays placed at regular intervals to keep the wires from tangling. The fence is flexible and resilient when struck by large animals, allowing elk, deer, and moose to pass over easily, yet immediately returns to shape and effectively contains livestock.

A wildlife friendly suspension fence uses no more than four wire strands. Anchor posts are spaced at least 50' apart, up to a maximum of 100' apart, or much closer in uneven terrain. Adequate bracing is essential to maintain wire tension. Posts may be treated wood, metal, or one of the commercially available bracing systems (for an example, see Southwest Fence Systems braces at www.swfence.com).

To maintain wire spacing, lightweight wood, fiberglass, or composite stays are evenly spaced between the posts. Be sure stays hang free of the ground and won't catch on vegetation and twist the fence as animals pass over. The stays also reduce tangling and improve visibility for wildlife and livestock. Twisted wire stays are not recommended, as they are easily bent by wildlife passing over the fence,



Jeff Laszlo

This suspension fence has a top smooth wire and the stays are unanchored poles, allowing the fence to flex as wildlife passes over or under. Fiberglass or composite stays can also be used.

increasing fence maintenance and the risk of entanglement.

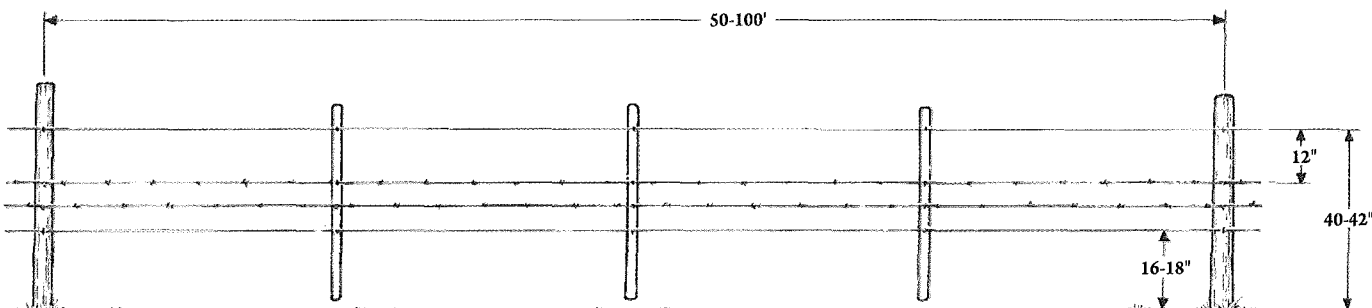
Place the top wire no higher than 40" to 42", the bottom wire at 18", and maintain 12" between the top two wires. A variety of barbed and smooth wire combinations can be used, depending on the situation. For example, use a bottom smooth wire where pronghorn or young deer, elk, or moose are present. A top smooth wire will aid passage for adult deer, elk, or moose. Use smooth wire for both bottom and top wires in areas with both pronghorn and elk, or both adult and young animals.

Suspension fence has the advantages of using far fewer posts than conventional fence – a savings in materials and labor, and a benefit where posts are difficult to drive. It also reduces or nearly eliminates long-term maintenance.

Wire Suspension Fence

- Place anchor posts 50' to 100' apart; closer in uneven terrain.
- Use sufficient bracing to maintain wire tension.
- Use a maximum of 4 wires: maximum 40" to 42" top wire, minimum 18" bottom wire, and 12" between the top two wires.
- Evenly space lightweight fence stays (wood, fiberglass, or composite) between the anchor posts. Easily bent wire stays are not recommended.
- Use smooth wire on top and bottom to ease wildlife passage.
- Suspension fence should be periodically checked for twisting, especially during peak migration/movement periods.

WIRE SUSPENSION FENCE



FENCE SOLUTIONS PUT TO THE TEST

Better Grazing, Thriving Streams and More Wildlife on the Granger Ranches

Jeff Laszlo is the fourth generation to operate the Granger Ranches, his family's traditional cattle ranch in Montana's Madison Valley. Spanning 13,000 acres between the soaring Madison Range and trout-laden Madison River, the ranch is a significant corridor for wildlife that move daily and seasonally through the valley, north and south, east and west.

In Jeff's grandfather's day, the family operated under the best understanding of husbandry of the time, draining wetlands, diverting streams, and creating a system of ditches to irrigate pastures. Today Jeff has taken a different approach to managing the ranch resources.

"We were looking for new ways to do business," he explains. In 2005, Jeff and his family undertook a long-term wetland and stream restoration project across the ranch. With technical expertise and financial help from a wide variety of non-profit, state and federal agency partners, Jeff has restored nearly 700 acres of river-bottom wetlands and 10 miles of spring-fed stream channels. The spring creeks once again hold trout, and in less than five years the birds have flourished from only 10 species to more than 100.

As part of the project, Jeff installed wildlife friendly suspension fence to keep his cattle out of the rejuvenating wetlands and streams while allowing wildlife to move through. FWP biologist at the time, Craig

On the Granger Ranches, extensive restoration of spring creeks and wetlands plus broad use of wildlife friendly fences have not only improved grazing and increased habitat for wildlife, but reduced fence maintenance.



"We were looking for a new way to do business," says Jeff Laszlo, 4th-generation owner of the Granger Ranches, seen here with his niece Caitlyn.

Jourdonnais offered help with the Granger Ranches' fence projects. "Working together leads to a lot of interesting possibilities," says Jeff. He liked the design so much he has installed wildlife friendly fence throughout the ranch, wherever old fences need replacement.

Jeff uses a 4-wire suspension fence, with his top wire no higher than 40" and bottom wire at 18" off the ground, the middle wires evenly spaced. Treated wood anchor posts are driven 50' apart and 3 wooden stays keep the wires spaced and taut. The fence then flexes and rebounds as elk, deer, or pronghorn pass over or under it.

On the uplands, where they have a lot of pronghorn, Jeff uses a smooth bottom wire to make passage under the fence easier. On the river bottom, they have more moose, so he reverses the design and uses a smooth top wire with three lower barbed wires.

"It's a better way to fence than standard 5-wire barbed," he explains. "First, we like

wildlife and have a lot on the ranch, and second, the suspension fence requires a lot less maintenance."

In addition to the permanent suspension fences, Jeff (in partnership with the Madison River Foundation) uses seasonal single poly-wire electric fence to intensively manage his grazing, especially in the river bottom where annual freezing and overflows make permanent fencing impossible to maintain. The seasonal fence allows Jeff to rotate pastures, control exactly where his cattle graze, and closely manage his grass.

"It produces better calves and leaves the land in better condition," Jeff explains. "It's important to me financially, but also important to me to leave better habitat. People value owning property with great wildlife values."

The intensive grazing management, he continues, "is especially important in a year like this with dry conditions and short grass. It's important to use the grass efficiently and not overuse it, which would potentially create costly issues – such as weeds and ground left less productive for future years."

"The typical ranch can't do this type of thing without partnerships, and that requires developing trust," Jeff adds. "I was willing to try a few things and learned there's a lot of common ground. We really appreciate the support that FWP has given the ranch. It has resulted in benefits for us as a ranch and for FWP's management of wildlife resources. It really makes sense for agricultural producers to use wildlife friendly fences, as they are less costly, allow for flexibility, and seem to last longer."



3-Wire High-Tensile Electric Fence

Researchers in Wyoming found that a flexible 3-wire high-tensile fence (with a hot – ground – hot configuration) is not only effective for containing cattle and bison, but also allows elk, mule deer and pronghorn to traverse the fence. They found that wild ungulates usually were not deterred by electric fences even with charges ranging from 0.5 and 4.5 joules, perhaps because of the insulating properties of their hair. Although wild ungulates were occasionally shocked when they nosed or bit a wire, or touched hot and grounded wires together, most animals readily negotiated the fences (Karhu and Anderson 2003, 2006).

Further, the researchers determined that 3-wire fences effectively contained bulls separated from cows coming into estrus, and calves from cows in the fall. Also, they found that a 3-wire fence was just as effective for containing bison as a 4-wire fence. A 2-wire fence can be used for areas without weaning calves but, curiously, pronghorn showed a high aversion to 2-wire fences, perhaps because of the novel height and their general reluctance to jump fences rather than crawl under (Karhu and Anderson 2003, 2006).

High-tensile fences require proper construction techniques, including



Rory Karhu

adequate braces, proper tensioning, care not to kink or break wire, and proper attachments and insulators for line posts and braces. The flexibility of the fence is key to allowing wildlife to pass over and through the fence. Fiberglass posts are used for all line posts, and wooden posts are used only for braces, direction changes, and gates.

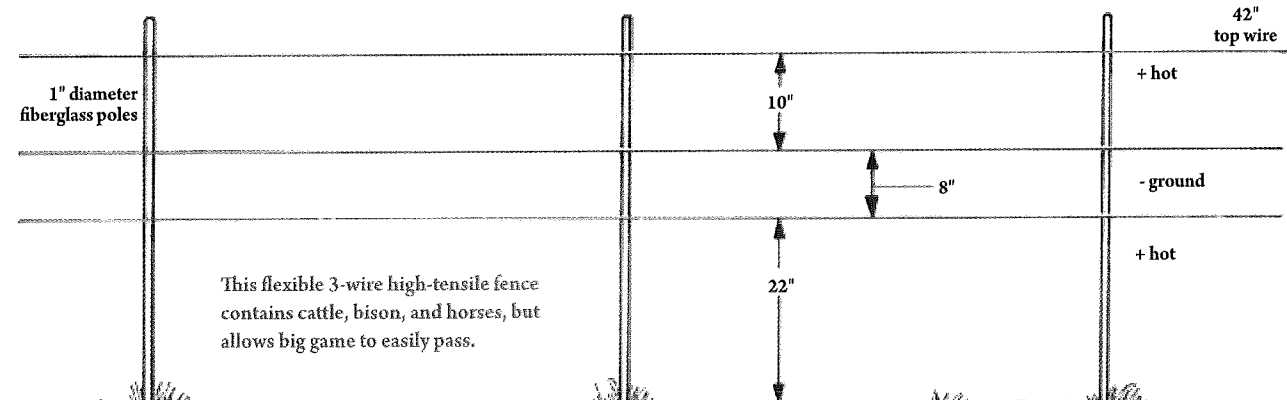
High-tensile fences need minimal maintenance, provide great strength, can be easily electrified, and will outlast most other fences. For technical details, see the Natural Resources Conservation Service (NRCS) specifications for permanent power fence (NRCS 2006a).

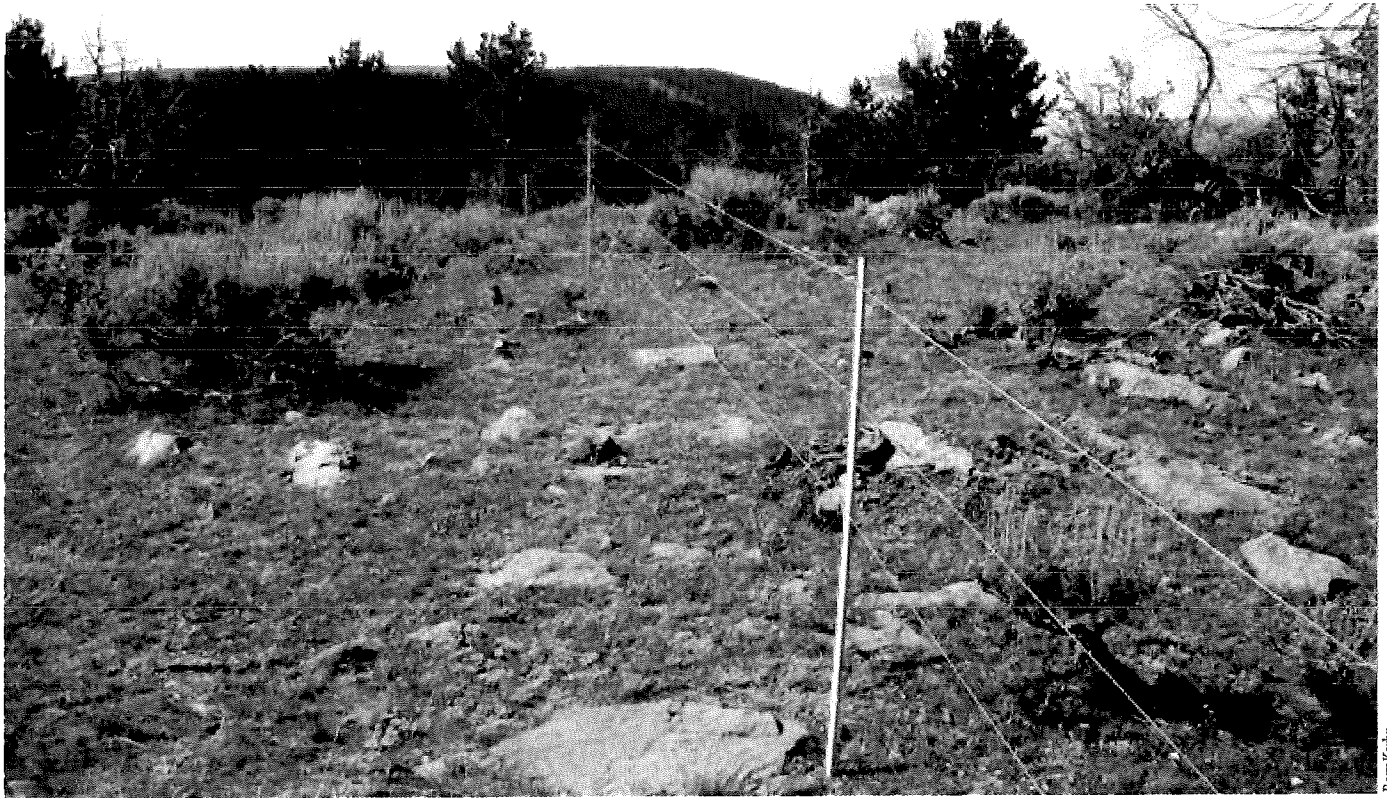
A 3-wire high-tensile electric fence is effective even for separating bulls from cows in estrus, and for containing bison. Using high-tensile wire at the proper tension is key to prevent wildlife damage.

Note that smooth high-tensile wire can be difficult for animals to see. Adding markers or survey flagging to the top wire can help. Commercial examples that work on smooth wire include the See-A-Fence flag (www.knifedgedgellc.com/seeafence.html) and Fence-flag (www.fenceflag.com).

Keeping the fence powered prevents wildlife from leaning into it. If power is off, consider laying the fence flat to the ground if it will not create an entanglement hazard.

3-WIRE HIGH-TENSILE ELECTRIC FENCE





Rory Karhu

3-Wire High-Tensile Electric Fence

Maintaining fence flexibility is key to allowing wildlife to traverse the fence.

- Use fiberglass line posts no greater than 1" in diameter.
- Brace fence with wood posts at least 5" in diameter; brace all corners, gates, and direction changes greater than 15 degrees. Appropriate insulators are needed with wooden posts.
- Space line posts 45' to 60' apart and do not use stays. Fence stays make it harder for wildlife to pass between the wires, and may cause the fence to flip.
- Smooth, 12.5-gauge, Class III galvanized wire with a tensile strength of 170,000 PSI and breaking strength of 1,308 lbs. is adequate.
- Increase visibility by using flagging, fence markers, or high-tensile wire coated for visibility.
- Top wire is hot; second wire is grounded; bottom wire is hot.
- Space wires at 22"-30"-40"/42" from the ground. The top wire should be no higher than 42", with 10" between the top two wires. The 10" spacing is necessary for cattle to contact both hot and ground wires, but poses little hazard for wildlife due to the fence's flexibility and lack of barbs. A bottom wire at 22" allows both young and adult wild animals to pass under easily.
- Connect wires to posts with metal clips or fasteners designed for electric fences; use porcelain insulators on wooden braces.
- Tighten wires to 150 lbs. tension. If too tight, the wires are more likely to break. Although high-tensile wire has a high breaking point, it is also more brittle, and breaks easily if tightly bent or kinked.
- Place solar energizer according to manufacturer recommendations.
- Ground fence properly according to the energizer instructions, and add extra ground rods as needed. Locate rods at fence ends and intermittently in between.
- Ground rods are relatively cheap, and extra rods will ensure the fence will be effective.
- When livestock aren't present, either drop the wires flat to the ground or keep the fence electrified to prevent wildlife damage. (Keeping the fence powered can also prevent the battery from freezing and prolong battery life.)
- Securely attach electric fence warning signs intermittently along the fence and at gates and crossing points.

FENCE SOLUTIONS PUT TO THE TEST

Power Fences on the Sun Ranch

Sun Ranch manager James Stuart and his crew keep pretty busy. The 18,000 deeded acres of the ranch, situated in the foothills of the Madison Range in southwest Montana, provide critical fall, winter, and spring habitat for thousands of elk, and year-round range for deer and pronghorn. All this wildlife traffic, combined with a summer grazing operation that brings on nearly 2,000 head of cattle, puts a lot of pressure on the fences.

Over the past decade, the Sun Ranch management has tried out innovative fence designs to improve wildlife passage without sacrificing the ability to hold cattle. To make room for experimentation, ranch staff has torn out more than 30 miles of problematic barbed wire fence over the course of the last decade, often with the help of volunteers from conservation groups like the Rocky Mountain Elk Foundation and Greater Yellowstone Coalition.

One of the simplest and most effective ways of reducing wildlife conflicts, James found, was using temporary fence wherever possible. His preferred design is a single strand of polywire – a woven mix of plastic strands and conductive wire about the diameter of baling twine – hung 36" high from fiberglass posts on 50-foot centers. Using a specially equipped wire buggy, two ranch hands can build this fence at a rate of half a mile per



Temporary single-strand electric poly-wire fence allows for easy manipulation of grazing patterns and highly permeable wildlife passage, while reducing fence maintenance.

hour, and pick it up again at a rate of two miles per hour. The ranch owns about 8 miles worth of posts, polywire, and solar-powered energizers, which they use extensively through the summer grazing season.

James stresses that the electrified polywire is a psychological barrier rather than a physical one, and that it helps to train cattle to respect it in a controlled environment. To do so, the crew builds a short stretch of power fence in a corner of their shipping pens, and expose new cattle to it as they arrive on the ranch. "One good shock," James says, "and they get the idea."

As a single-strand fence, the polywire is easy for wildlife to negotiate. Although elk and deer can damage it, especially if they come through in the night, James believes that temporary fence has been an extremely effective tool for improving wildlife passage, manipulating livestock grazing patterns, and reducing time spent repairing fence in the spring.

Where the crew built new permanent fences, two designs emerged as especially effective. One is a three-wire let-down electric fence built with wood posts and pin-lock insulators. Following the grazing season, all three high-tensile wires are dropped to the ground, where they stay all winter. **The extra work of raising and lowering these fences twice a year, says James, is nothing compared to patching elk damage in traditional barbed wire fences.**

The other key design is a two-wire electric fence hung from one-inch diameter fiberglass posts on 50-foot centers. The top wire is hot, and hung 32" from the ground. The grounded bottom wire runs 12" below it. "Pronghorn go under easily, and everything else goes over. Because the fiberglass posts can flex, the fence tends to bend instead of break", James says. **Although a two-wire fence may seem like an insubstantial barrier, James stresses that it contains cattle very well, and that he'll be building more of it in the future.**

– Bryce Andrews





Openings, Crossings, and Passes

You can include crossings in any fence design to allow passage for wildlife, especially when livestock are not present. Short sections can be altered to wildlife friendly standards to help wildlife cross, or gaps, openings and jumps can be added.

Fence passes keep fawns and calves from being stranded, provide openings for other animals unable to jump fences, and help wildlife cross when snow hinders passage over or under fences.

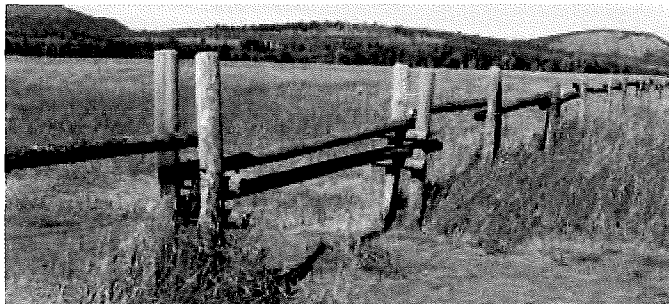
Wildlife crossings are especially important when fawns and calves are small, from June 1 through the summer, and for seasonal wildlife movements and



Scott Nicolaisen

ranges. Such openings can considerably reduce wildlife damage to fences and decrease maintenance costs.

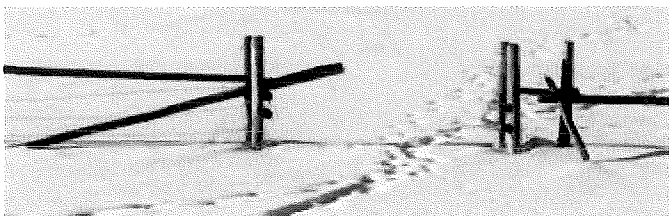
Elk and other wildlife readily travel through seasonal fence openings. Here a wildlife gate is installed on an elk trail.



Christine Paige



Bert Lindler



Christine Paige

Fence alterations can include:

- Lowering the top wire or rail to 42" or less.
- Increasing the distance between top and second wires to 12".
- Raising the bottom wire or rail to 16" minimum, and preferably 18" or more.
- Replacing the bottom and top wires with smooth wire.
- Increasing visibility with a top rail, PVC pipe, high-visibility tape, braid, or markers.

Wildlife openings and passes can include:

- Gates secured open.
- Dropped rails and wildlife jumps.
- Sections with adjustable wires or rails.
- Sections of seasonal lay-down fence.
- PVC modifications for big game and pronghorn passage.

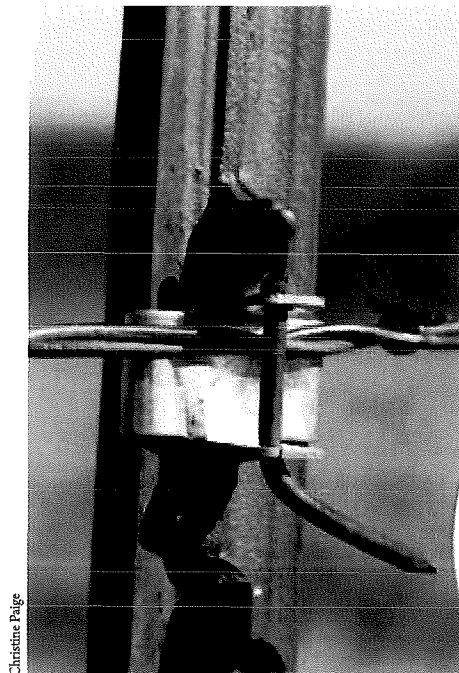
Use your local topography and patterns of wildlife travel to help you determine the best placement for crossings. Look for signs of wildlife use and travel such as game trails, tufts of hair caught on fence wires, trails to water, or gullies and swales that act as wildlife corridors.



Friendly Designs

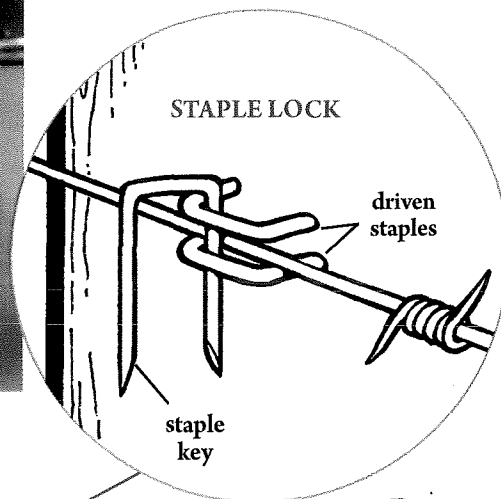
Adjustable Wire Fence

Adjusting the height of one or more wires is an easy and effective way to allow animals to cross during migration periods if livestock aren't present. Drop the top wire to the level of the second wire, either in sections or along an entire run of fence, to allow wildlife to jump over easily. Lowering the top wire to 25" or less allows elk and deer to hop over easily in almost all conditions. Raise the lowest wire in the same way to help wildlife crawl under. A simple staple lock allows wires to be rapidly adjusted from one level to another, and the wires can be adjusted by only one person.

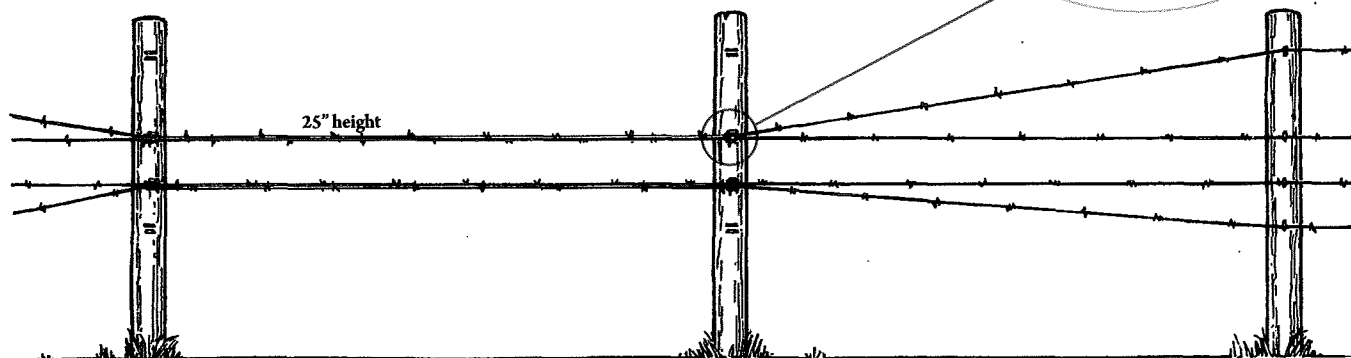


Christine Paige

Existing fences can be readily modified by installing staple locks to create a drop wire so wire height can be adjusted when livestock are not present.



ADJUSTABLE FENCE FOR SEASONAL WILDLIFE PASSAGE



Staple lock for wooden posts

- Install two fence staples horizontally and less than an inch apart on each post at the level of both the top wire and the second wire.
- Slip the fence wire between the two staples.
- Secure it in place by hooking a third staple through the paired staples vertically, like a latch.



Marina Smith

FENCE SOLUTIONS PUT TO THE TEST

Searching for Solutions in the Madison Valley

Marina Smith knows as well as anyone how difficult it is to reconcile the needs of livestock and wildlife: she's been managing ranches at the south end of the Madison Valley for years. The properties in her charge sit astride an antelope migration corridor and provide crucial habitat for elk and deer.

Initially, these lands had woven wire and jackleg fence, and wildlife conflicts were commonplace. On one occasion, a black bear was stranded between a highway and a woven wire fence. Panicked, the bear tested the fence repeatedly, unable to pass through or over it.

Marina's challenge was to replace fences like this one with new designs more permeable to wildlife, but that would also reliably hold cattle for summer grazing.

Marina has torn out close to 30 miles of old fence. She has experimented with various fence designs – with mixed results. On the Elk Meadows property, she installed stretches of high-tensile electrified fence. These fences were highly effective for livestock containment when fully charged. However, many of the electric fences ran through areas with steep topography, rocky soil, and much wildlife traffic, making them susceptible to wildlife damage and difficult to maintain.

Marina also theorizes that wildlife have a hard time seeing the electric fences, as they can be built with thinner posts and fewer wires than traditional fences. Wildlife collisions frequently grounded out the fence, reducing its ability to hold cattle. (This

problem might be mitigated by using high-visibility wire, flagging, or other markers.) Sections of suspension fence, where posts were set at relatively long distances from each other and the wire spans were stiffened with wire or wood stays, fared even worse. In the process of crossing, elk would often cause the fence to twist. When inverted, the stays would catch on the ground, compromising the fence.

Marina found that the design that best balances her livestock production needs with her desire to enhance and protect wildlife habitat is a four-strand barbed-wire fence with a drop-down top wire. The top wire is hung at 42" inches and secured with a staple lock; the bottom wire is 18" from the ground. During fall and winter, in areas that serve as movement corridors for wildlife, Marina drops the top wire to 36". **Observing the way animals interact with the drop-wire fence has led Marina to conclude that these wire heights are critical for allowing wildlife passage.**

– Bryce Andrews

Ranch manager Marina Smith found that a seasonal drop-down top wire allows migrating elk to easily pass over the fence in fall and winter.





Friendly Designs

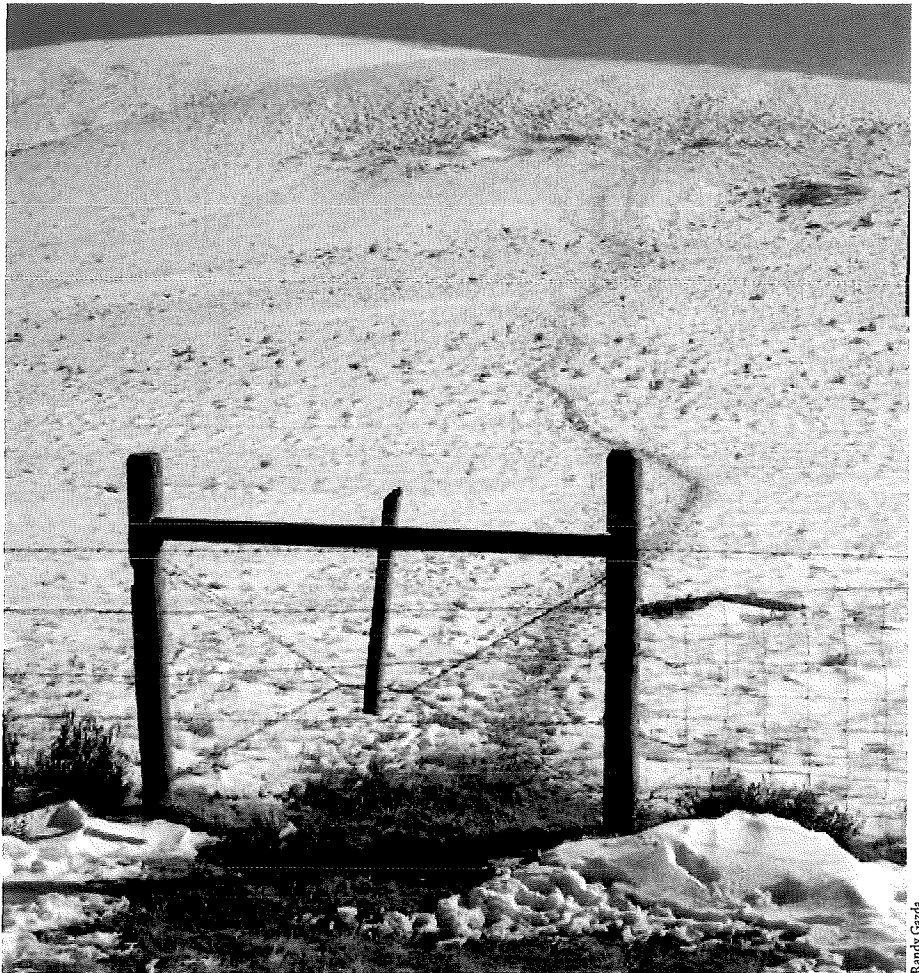
Pronghorn Underpass or "Goat Bar"

Although capable of jumping even high fences in extreme situations, pronghorn prefer to crawl under fences, and almost seem unaware of their ability to "high jump." They will often run for miles looking for fence openings or spots to crawl under a fence, and have been known to die of starvation in winter when blocked by a fence they see as impassable.

In Sheep Range:

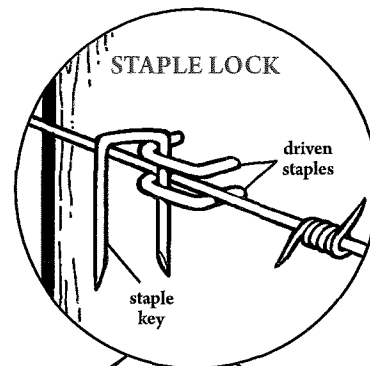
Pronghorn have the greatest difficulty negotiating sheep fence, which either uses barbed wire strands lower than cattle and horse fence, or is typically made of woven wire. However, a pronghorn "underpass" can be created by raising the bottom strand in selected fence sections.

- For sheep, space wire strands at 10"–16"–22"–32" above the ground, the top three strands barbed wire, the bottom strand smooth wire.
- In selected sections, raise the bottom smooth wire on two posts to the height of the third wire, securing in place with a staple lock. The smooth wire can be dropped again if needed.

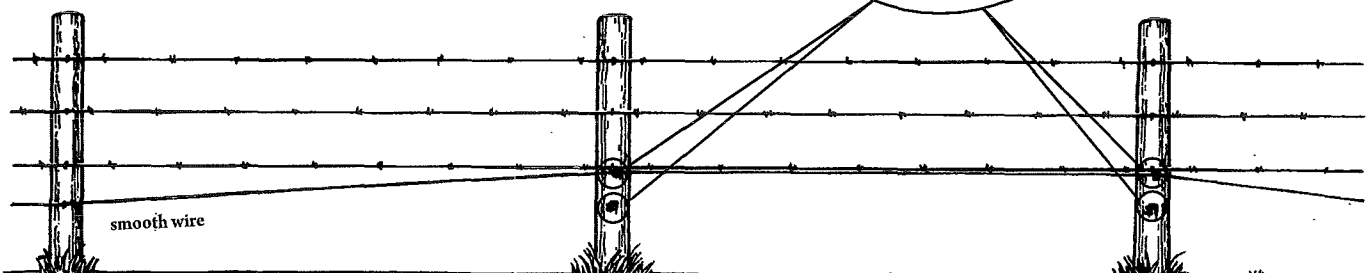


Randy Gazda

Pronghorn will readily use any section with a slightly raised bottom wire to crawl under a fence.

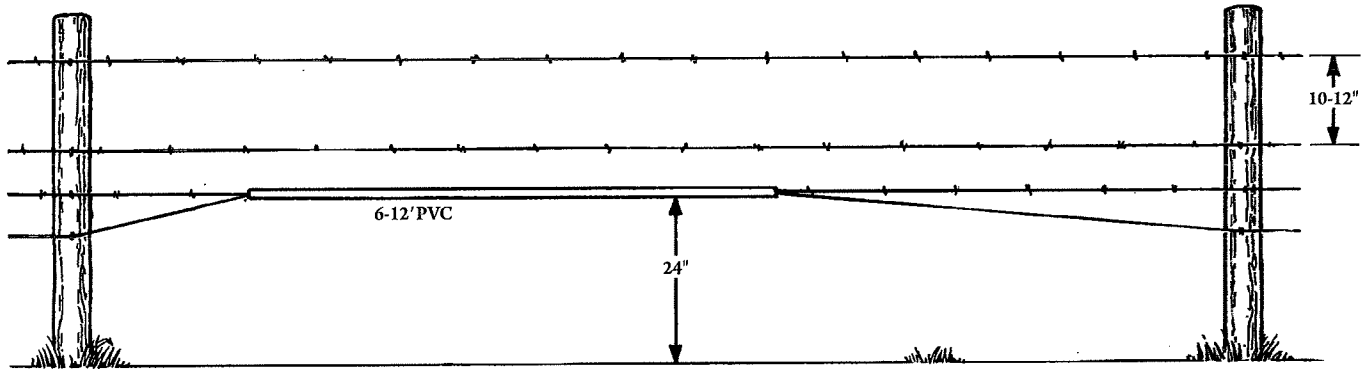


PRONGHORN UNDERPASS FENCE WITH RAISED WIRE





PRONGHORN UNDERPASS FENCE WITH GOAT BAR



In Cattle and Horse Range:

Where cattle or horses share the range with pronghorn, a PVC underpass, or "goat bar," can be created by simply gathering the bottom two wires in a PVC pipe to make a higher clearing for pronghorn of any age to crawl under. Despite the underpass, the fence remains effective for controlling horses and cattle. This design has been used extensively in pronghorn habitat.

- Space fence wires heights at 18"-24"-30"-40"; use smooth wire on the bottom.
- Cut several 6' to 12' lengths of PVC pipe.

- With a table saw, cut a 1/4" slot the length of each PVC pipe. Note that a 1/4" cut can be made by matching up two 1/8" wide blades and using a wood guide.
- Grip the bottom two fence wires together, and feed the PVC pipe onto the wire from one end of the pipe. If the pipe gets hung up on a barb at the fore-end, work the barb into the end of the pipe and continue. Once the pipe has been adequately started, grip the pipe near the fore-end and begin pulling down the length of the wire.

- Space these underpasses intermittently along the fence, and especially in fence corners where pronghorn may be directed by the run of fence.
- Add a PVC pipe threaded onto the top wire or top two wires to allow passage for deer and elk as well. The PVC greatly reduces the chance of snagging, injury and entanglement.
- Use two or three cable zip-ties to close up the gap on the PVC.

Pronghorn will seek places they can easily pass under a fence. Keep brush clear and take advantage of small gullies and swales to provide pronghorn passage.



FENCE SOLUTIONS PUT TO THE TEST

Pronghorn Know No Boundaries

The music of the wind is a constant companion on the sweep of native prairie that stretches across Montana, Alberta, and Saskatchewan. Once covered by glaciers, these northern plains are now blanketed by grasslands and sagebrush shrub-steppe, dimpled with pothole wetlands and gouged by craggy badlands. Late into the 19th century, massive herds of bison flowed across this landscape, and with them elk, pronghorn, mule deer, and their predators. Although the great bison herds are gone, pronghorn have held on in this northern limit of their range, claiming dual citizenship as they migrate across the international border between seasonal ranges.

Today the glacial soils of this wide-open country support grain farms and ranches, but the fences that divide and protect croplands and rangeland prove a constant challenge to pronghorn as they follow their ancient migration paths.

Pronghorn Pathways

In 2007, state and provincial wildlife agencies in Montana, Alberta, and Saskatchewan formed the Northern Sagebrush Steppe Initiative (NSSI). The goal was to help sustain the northern prairie's wildlife populations by sharing data and promoting collaborative research. In 2008, the NSSI and researchers at the University of Calgary launched the Transboundary Pronghorn Project with support from the Alberta Conservation Association, Saskatchewan



Ken Plourde, University of Montana wildlife biology student, lends a hand rolling up old woven wire that was replaced with pronghorn-friendly fence.

Ministry of Environment, U.S. Bureau of Land Management, and World Wildlife Fund. The project uses data from two recent studies of GIS-collared pronghorn in Alberta (72 individuals) and Montana/Saskatchewan (111 animals) to understand their seasonal movements and pathways across the entire region.

Maps of the collared animals' daily and seasonal movements clearly show where pronghorn are hindered by fences, sometimes spending several days attempting to find a way through or around. Because pronghorn are adapted to open grass ranges and sagebrush steppes, where the tallest objects are sagebrush, they are usually

reluctant to jump over fences. Despite an ability to jump, they prefer instead to crawl under and are often blocked by woven wire fence or barbed wire fence with wires low to the ground.

Cooperative Solutions

Removing obsolete fences or modifying existing fence can allow pronghorn to slip through without missing a beat. A collaboration among the University of Calgary researchers, the Montana Chapter of The Nature Conservancy (TNC), FWP, and area livestock growers is removing the barriers for pronghorn once again.

TNC has a long history of partnership and stewardship with private landowners in northeastern Montana. On the Conservancy's Matador Ranch, a 60,000-acre preserve in Phillips County, TNC runs a program of community grassbank leases. Under the program, local ranchers help manage the grassbank and pay discounted fees to graze their cattle on the Matador Ranch in exchange for wildlife conservation practices on their own operations, including wildlife friendly fencing. TNC also works with private landowners to develop conservation easements to sustain native grasslands and working lands.

TNC was awarded a grant to integrate the NSSI pronghorn research into on-the-ground conservation. Using the data to identify specific sites where pronghorn meet barriers, TNC works with private landowners to remove or modify fences.

Shawn Cleveland

Cattle, sheep, and pronghorn

On the Barthelmess Ranch, run by brothers Leo and Chris Barthelmess, the family has partnered with TNC, National Resources Conservation Service (NRCS), and FWP on several projects to sustain pronghorn migration. The family has a tradition of sustainable ranching – using best-management practices to provide for their livestock and protect the soil and water resources. They also highly value the wildlife on their ranch, from large game to birds.

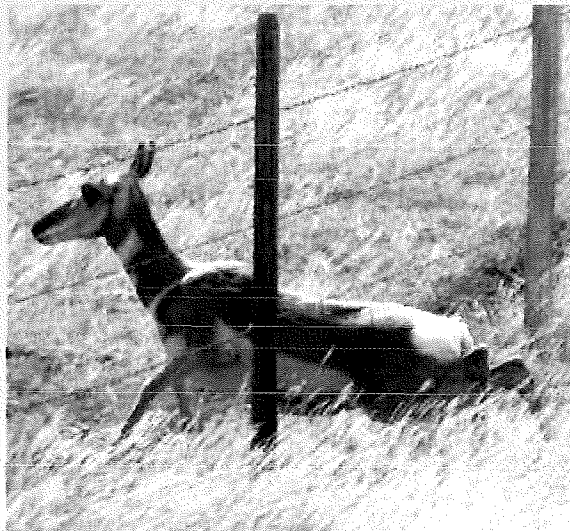
"Why do this? There are three reasons," says Leo. "One is that wildlife is important to our community and us. A second reason is we are seeing reduced maintenance on fences that are modified to allow for wildlife passage. And third, there are people and agencies that will invest resources to help us do this."

One project removed one-half mile of woven wire fence and replaced it with a combination of smooth and barbed wire fence that meets wildlife friendly standards. The new fence uses a smooth wire on the bottom, a top wire no higher than 42", and at least 12" between the top two wires. Although the family raises sheep in addition to cattle, they have eliminated all woven wire fence on their ranch. Yet the new fence design effectively contains their livestock, which do not pressure the fences due to good husbandry and plentiful forage.

"Recently, I spent a day maintaining an old fence line that had not yet had the wire spacing modified for wildlife migration" says Leo. As I came to areas that indicated substantial antelope migration – the bottom wire was broken or stretched far off line – I raised the bottom wire until it was 18 or more inches off the ground. I anticipate in the future that there will be little need for additional maintenance on these portions because of wildlife damage. In the future, I will monitor these fence adjustments and see if the antelope consistently use these crossing areas as opposed to making new ones."

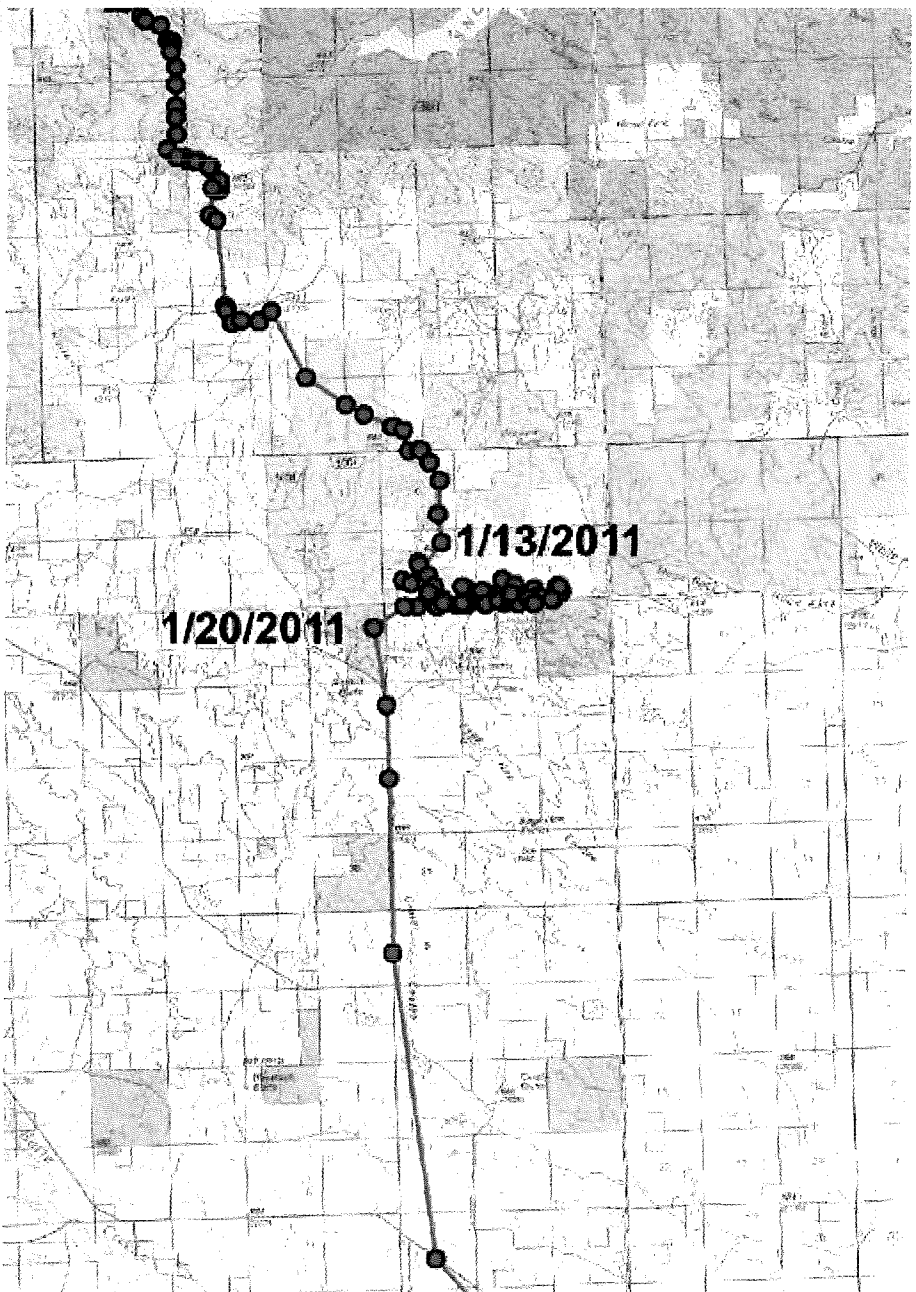
Leo concludes, "It is our best hope that these efforts will aid in the survival of wildlife migration routes and help us continue to ranch sustainably in the future."

Samantha Howlett



A pronghorn doe slips easily under a fence modified so the bottom wire is at least 16" to 18" off the ground.

Telemetry research on collared pronghorn show distinctly where animals are hindered by fences along their migration, sometimes delaying them by several days.



Courtesy of Andrew Jakes

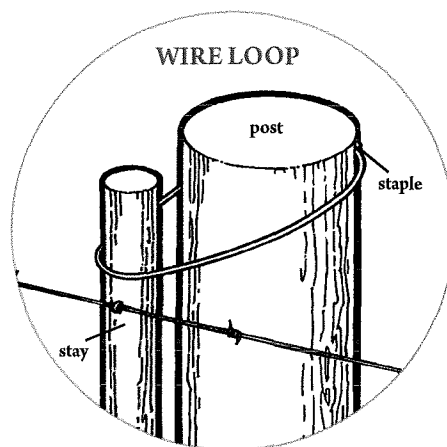


Lay-Down Fence

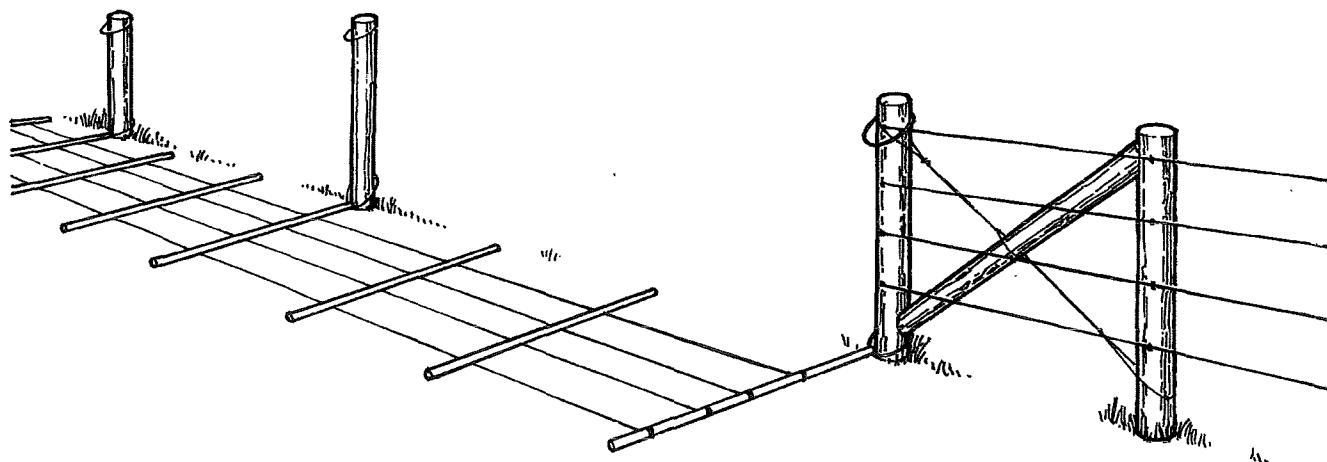
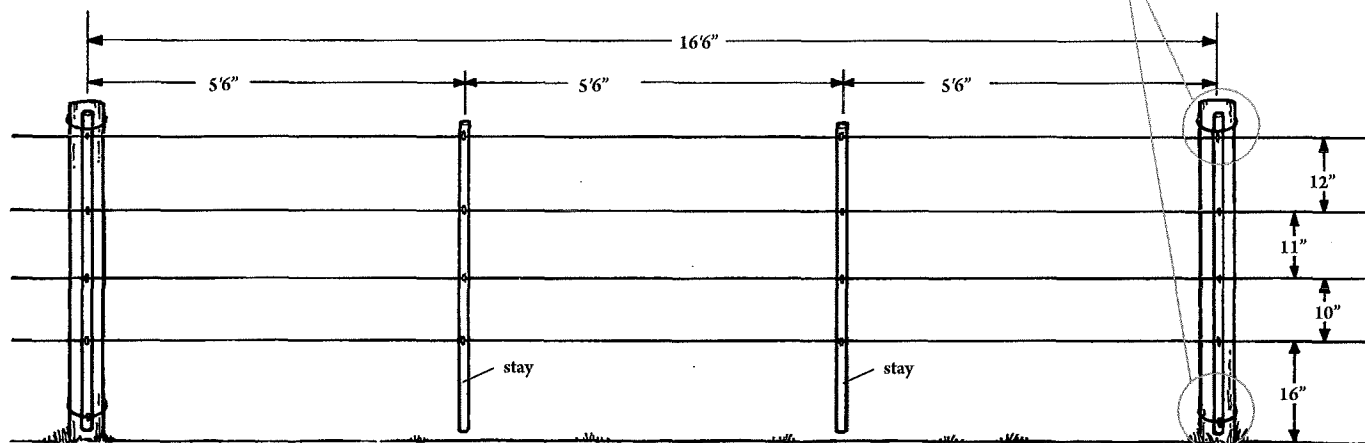
A lay-down fence is a standard 3-wire or 4-wire fence that can be laid on the ground as a unit to allow ungulates to pass through during migration or seasonal use. A lay-down fence can also reduce snow and wildlife damage and save maintenance costs. Most designs allow a single person working alone to let the fence down or put it back up.

Lay-down fence can be constructed from smooth wire or barbed wire. Fence posts can be wooden or steel, but wood is more durable in heavy snow areas. Posts should be spaced at 16.5' intervals.

For barbed or smooth wire fence, one to two stays are needed between fence posts, plus a stay lined up with each fence post. Wire loops, secured at the top and bottom of the fence posts, support the fence stays. The lay-down section can then be dropped by flipping up the top loop and lifting the stays out of the bottom loop.



LAY-DOWN FENCE





Montana Fish, Wildlife & Parks



Jay Kolbe

This lay-down fence using 4-strand smooth wire was constructed along 1.5 miles of fenceline next to the Blackfoot-Clearwater Wildlife Management Area in Montana to allow winter passage for elk. The number of elk tracks attest to the design's success.



Christine Paige



Friendly Designs

Durable PVC Big Game Passage

Installing PVC pipe over bunched fence wires is an inexpensive way to allow elk, deer, and antelope to freely cross existing barbed wire fence with minimal risk. **This design is especially useful where elk, moose, or other ungulates cross heavily traveled roadways and have difficulty crossing a fence. This delays them from moving out of danger, particularly in spring and summer when calves are small. Along roads, the PVC passage should be installed on both sides of the right-of-way.**

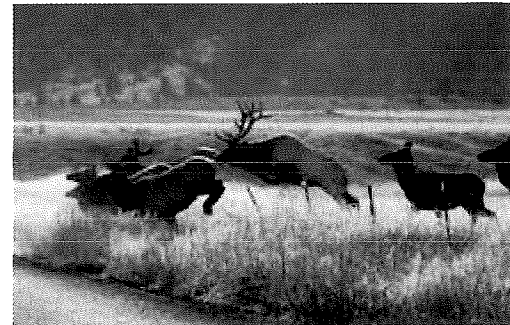
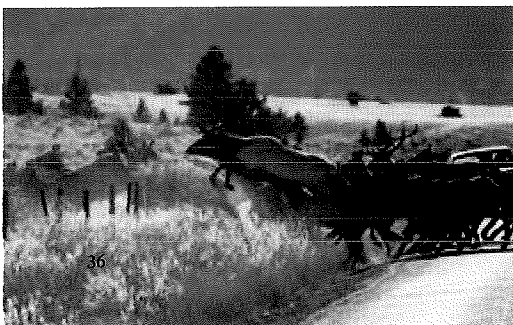
PVC pipe threaded over bunched fence wires creates an effective and durable big game passage, especially on road right-of-ways.



Montana Fish, Wildlife & Parks



Montana Fish, Wildlife & Parks





PVC Game Passage for Wire Fence

These instructions are for a metal t-post, 5-strand barbed wire fence, with no livestock present, but can be adapted for other situations.

Materials:

To modify two 60' sections of barbed wire fence.

- Twenty 10' sections of 1.5" OD PVC pipe
- One 100-count bag of large (7" or 11") UV-resistant plastic cable ties
- #16 or larger soft wire
- fencing pliers, wire cutter, leather gloves

Before Installation:

With a table saw, cut a 1/4" slot the entire length of each PVC pipe. Note that a 1/4" cut can be made by matching up two 1/8"-wide blades and using a wood guide.

Installation:

Step 1: Remove all wire clips from about 60' or three fence posts and allow wire to hang freely.

Step 2: Beginning near first post, with clips removed, grip the top three strands of wire and pinch together. Locate a space between barbs that will allow you to thread on the PVC pipe. Push pipe onto wire (not wire into pipe) concentrating on fore-end of pipe. If the pipe gets hung up on a barb at the fore-end, work barb into end of pipe and continue. Once the pipe has been adequately started, grip pipe near the fore-end and begin pulling down the length of the wire. The wire will feed itself into the pipe. Pull pipe down the wire until about 8' from where posts with clipped wires resume.

Step 3: Repeat with three more pipes. Space the joint between two pipes at a post where possible. This will allow you to clip the three wires together to a post.

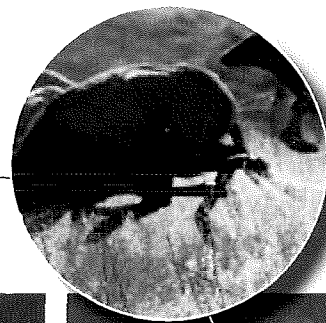
Step 4: The last (fifth) pipe must be installed in the reverse direction. Starting near the end of the fourth pipe, find a space between barbs and install pipe as in Step 2, push into place 8' from where posts with clips resume.

Step 5: Repeat steps 2 through 4 with the bottom two wires.

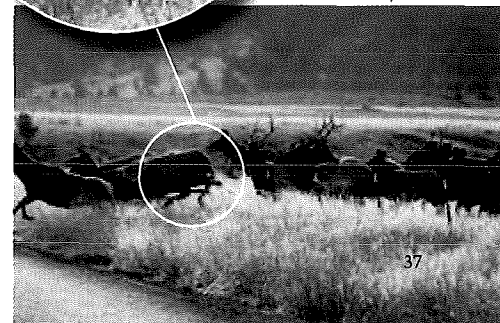
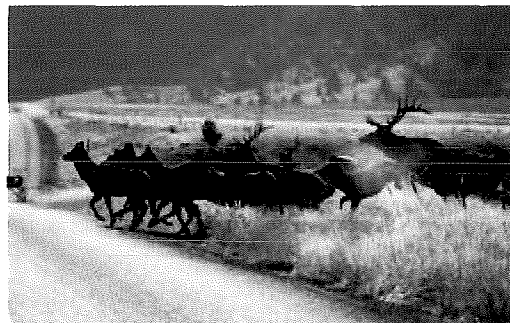
Step 6: Using #16 or larger soft wire, attach the top PVC pipe to posts no more than 40" above the ground. Attach the bottom pipe at 18" above the ground, or dropped closer to the ground to create a larger middle gap for deer fawns or elk calves to go through rather than under. Where a joint between pipes is located at a post, enough space can be left to clip the wires to the post.

Step 7: Attach three cable ties per 10' section of PVC pipe, one near each end and one in the middle. Squeeze PVC pipe while pulling cable tie tight. Gap from cut will not be completely closed but will be small enough to allow the pipe to roll and not work its way off the wire. Clip tag end of cable tie.

Step 8: Repeat on opposite side of right-of-way.



An elk herd races to cross a highway. Animals are especially vulnerable to tangling when alarmed or crowded by others.



Shawn Bryant



Highway Right-of-Way Fence

Fences along state highway right-of-ways (ROW) present special challenges for landowners and wildlife. While fences protect livestock and crops, and keep livestock from entering the ROW and endangering motorists, some types of fence can restrict wildlife passage and migration, and animals trapped within the ROW are more likely to collide with vehicles.

Montana Department of Transportation (MDT) encourages the use of wildlife friendly fence designs that promote permeability for wildlife, allow animals to pass quickly out of the highway ROW, and minimize animal-vehicle collisions. Ideally, similar fence types should be placed opposite each other on either side of the ROW.

Depending on the situation, MDT can opt to:

- 1) replace existing and functional fence with a fence that is no more restrictive to wildlife movement than existing fence;
- 2) encourage landowners with functional ROW fence to replace the fence with wildlife friendly fencing in whole or at select locations;
- 3) replace dilapidated and non-functional ROW fencing with wildlife friendly fencing; or
- 4) not replace the dilapidated fence at all.

MDT currently offers several designs for wildlife friendly fence. The preferred design is four strands with top and bottom smooth wire and two center barbed wires; the top wire at 42," a 12" spacing

Wildlife Friendly Highway ROW Fence

Wildlife friendly fence and crossings should be placed on both sides of the ROW to allow animals to move quickly out of harm's way. Using wildlife friendly fence along highways:

- Allows wildlife to cross roadways easily and quickly.
- Reduces the time animals spend in the ROW.
- Reduces the chance of animals being trapped in the ROW.
- May reduce the number of animal/vehicle collisions.
- Maintains habitat connectivity for wildlife.
- Restrains domestic livestock from entering the ROW.
- Reduces wildlife damage to fences, reducing the need for fence maintenance.

between top and second wire, and bottom wire at least 16" off the ground. Landowners can choose to use one of MDT's standard designs or propose other wildlife friendly specifications that will work with their land use practices. MDT encourages landowners to use wildlife friendly fence either along the full length of their property along the ROW, or at a

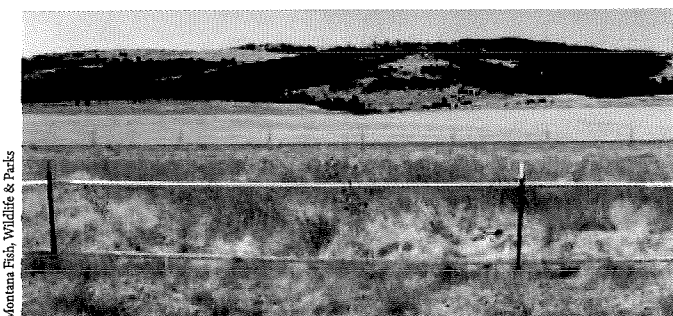
minimum at regular intervals and known game pathways to provide crossings.

MDT is open to innovative solutions and will work with landowners to find solutions that accommodate their needs while providing wildlife movement across the highway corridor. Contact MDT Environmental Services for more information: (406) 444-7228.



Courtesy Montana Dept. of Transportation

Top and bottom smooth wires provide wildlife friendly passage where the Manley Ranch borders the Hwy 271 ROW near Helmville, Montana. The family reports that their cows respect the fence, wildlife pass through easily, and the fence hasn't required any maintenance.



Montana Fish, Wildlife & Parks

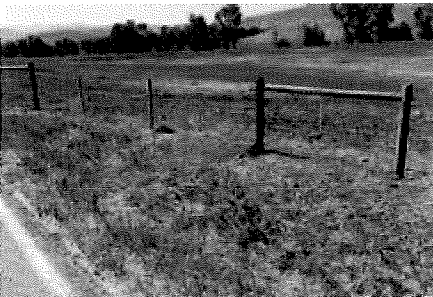
Wires gathered into PVC pipes create an easy big game passage on either side of the ROW when cattle are not present.



MDT Options for Wildlife Friendly Highway Right-of-Way Fence

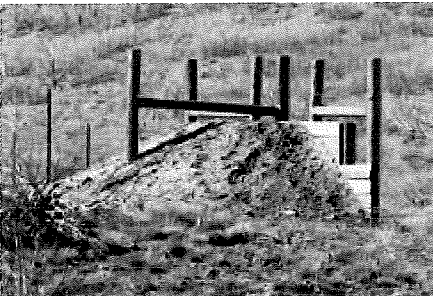


John Carlson



Bert Lindler

An elk crossing with plastic-coated top and bottom wires allows quick passage out of the right-of-way, while center barbed wires still hold cattle.

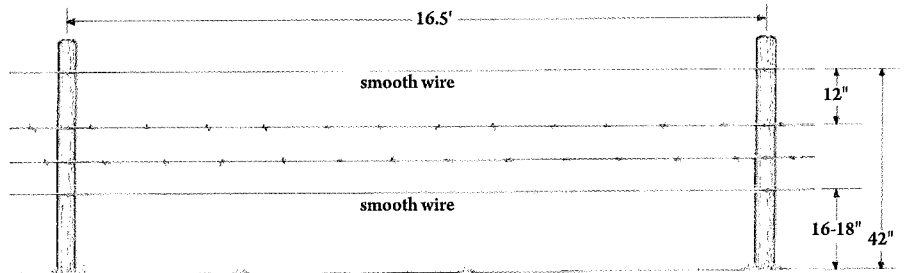


Christine Paige

In some situations, the highway department may install wildlife jumps, which are one-way ramps that allow animals to escape the highway ROW.

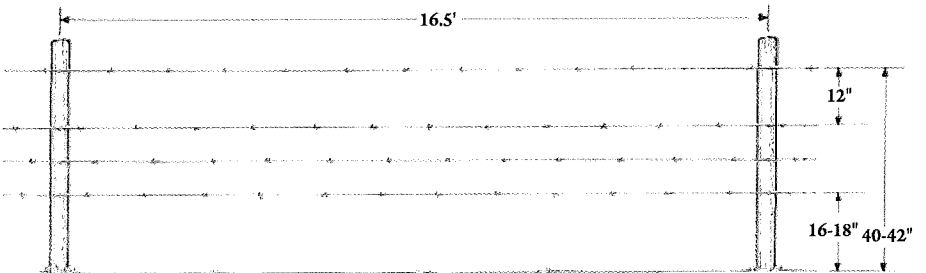
Preferred Fence

Top and bottom smooth wires allow the easiest passage for wildlife. The standard wire heights are 16" - 18" bottom wire, 40" - 42" top wire, and 12" between the top two wires to minimize entanglements.



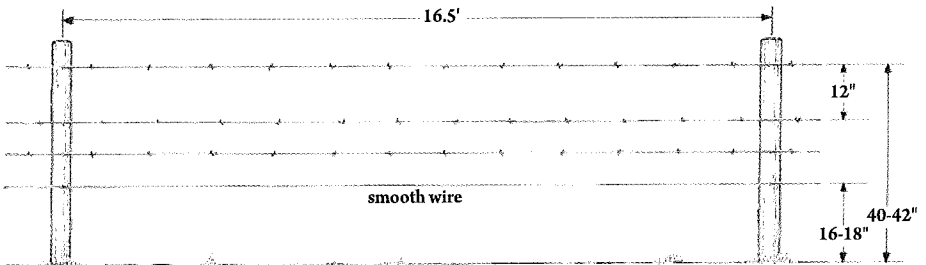
Basic All-Barbed Wire

In cases where all-barbed wire is needed, adjusted wire heights can make wildlife passage easier.



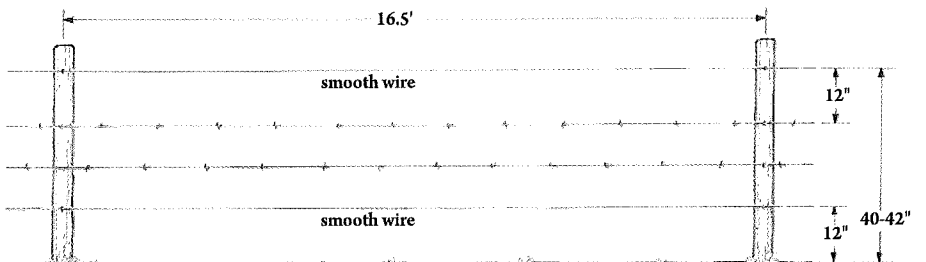
Pronghorn Fence

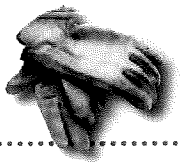
A smooth bottom wire at 16" - 18" minimum above the ground is recommended for pronghorn country, or where young ungulates are common.



Fence for Sheep and New Calves

A 12" bottom wire should only be used in areas without pronghorn, or for operations where a low wire is necessary, such as for sheep and very young calves.





Friendly Designs

Wildlife Crossings for Established Fences Along Highway ROW

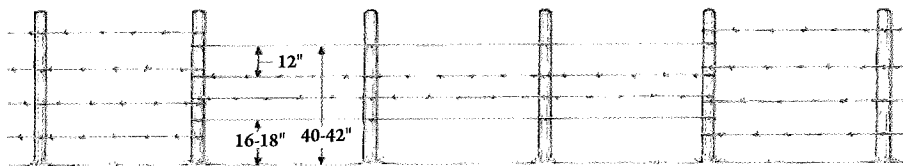
Wildlife Jumps, Underpasses, and Overpasses

Along major highways with high-speed traffic, the highway department may opt to install tall barrier fence with wildlife underpasses, overpasses, or jumps. This solution is very costly and

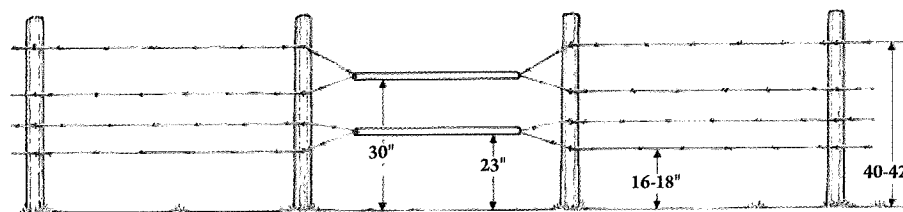
should only be employed where the risk of vehicle/wildlife collision is very high.

Underpasses and overpasses are major construction projects, and require thoughtful design and an understanding of wildlife behavior to be effective. Wildlife jumps are ramps that allow animals to escape the highway ROW but prevent entry. Jumps should be placed at frequent intervals to minimize the time animals are searching for a way out of the ROW.

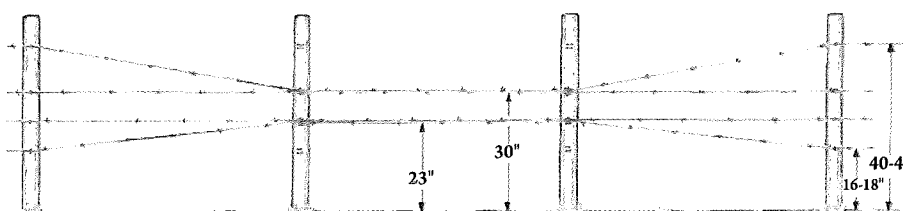
Wildlife friendly section: short of modifying an entire fence, sections of wildlife friendly design can be used in areas of known migration or movement.



PVC wildlife passage: the top two and bottom two wires are gathered into PVC covers to create an easy passage. See full description on pages 37-38.



Dropped wire passage: staple locks can be used to drop top wire and/or raise the bottom wire for passage. See full description on page 29.



Working With MDT

MDT encourages the use of wildlife friendly designs, but will work with landowners to install appropriate fences for their land-use needs.

For each project, an MDT biologist considers the impacts of the ROW fence on wildlife movement patterns and landscape connectivity. The biologist evaluates the surrounding topography, road geometry, traffic volumes, adjacent habitat and land-use practices, existing fence types, animal-vehicle collision, and roadkill data. Based on this information, the biologist makes recommendations for wildlife mitigation strategies, including fence configurations.

An MDT ROW agent will meet with the landowner to negotiate ROW acquisitions for the project, and negotiate the type of ROW fence to be used along the property. The ROW agent and biologist coordinate to recommend an appropriate fence design that will work both for wildlife and the landowner. The biologist is also available to meet with landowners to discuss fencing recommendations or alternative solutions.

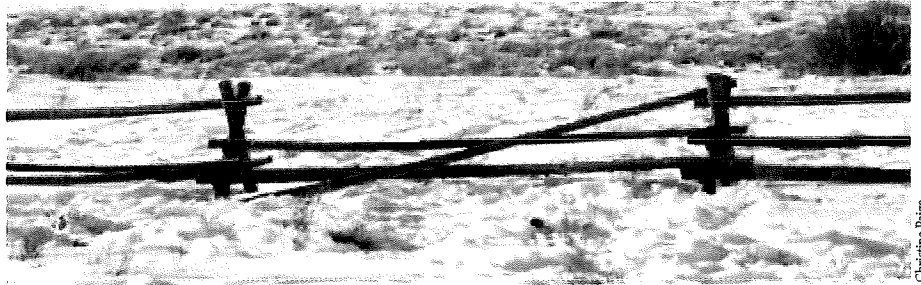
Currently, the ROW fencing is negotiable with the landowner. In some instances, MDT has placed the fencing on the MDT ROW in order to ensure implementation of the recommended fence design. If a fence is installed within the ROW, MDT maintains the fence, while the landowner is responsible for maintenance of the fence if it is placed on their property or at the ROW boundary.



Dropped Rail Wildlife Passage

Buck and rail or jackleg, post-and-rail, and worm or zigzag fences are often used for property boundary fences, but may be difficult for wildlife to negotiate. Often these fences are built too high, too wide, with extra wire, or with rails spaced too closely together for wildlife to pass through.

An occasional gap in the fence can provide a crossing, particularly when livestock are not present. Simply drop

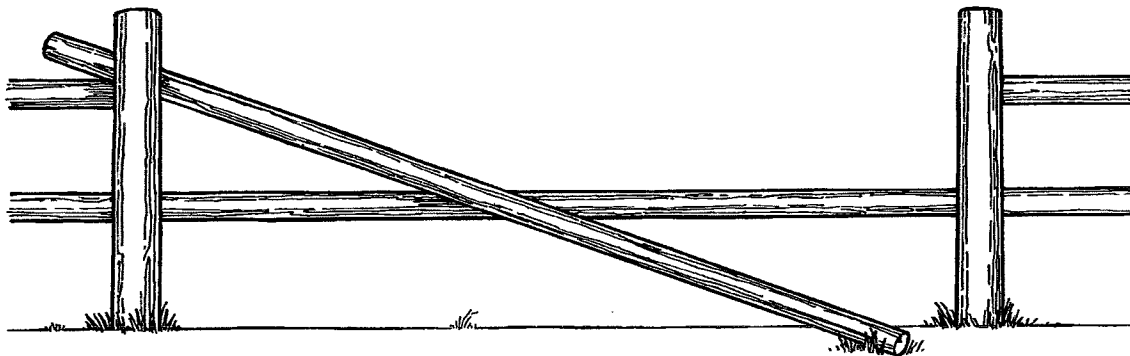


Christine Paige

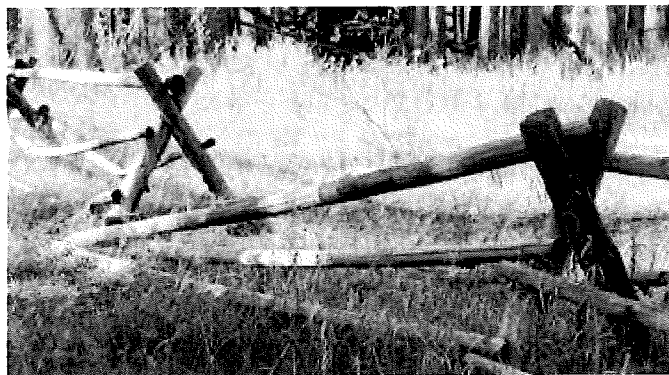
the top rails to the ground intermittently, such as every 100', to allow animals to step across. Animals will often move along the length of a fence seeking an

opening. Rails should be dropped where there are signs of wildlife passage, such as game trails, and in stream corridors, gullies, or other natural funnels.

DROPPED RAIL FOR WILDLIFE JUMP

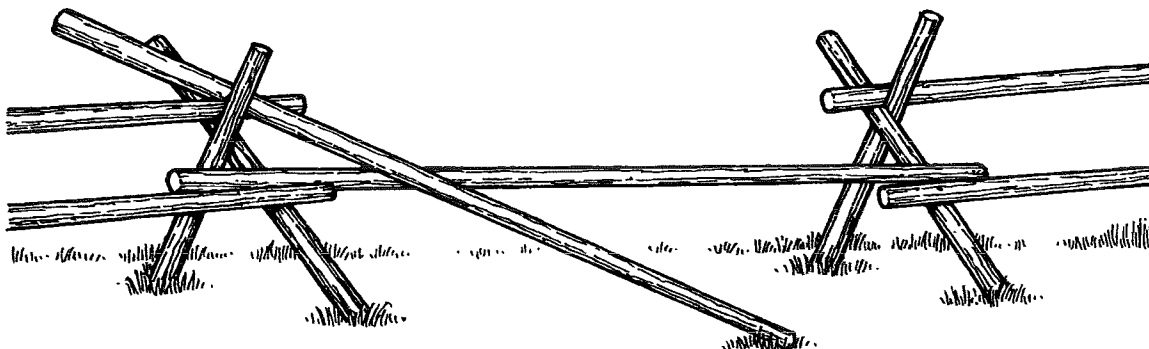


Wildlife can often see openings in a fence from a distance and will quickly learn to use these passages.



Christine Paige

DROPPED RAIL IN JACKLEG





Remedies for Existing Fences

Remedies for Existing Fences

How can you make existing fences more wildlife friendly?

Fence maintenance, modifications, and removal can all help wildlife.

You can modify nearly any existing fence to be friendlier for wildlife. If you do not plan to completely replace an existing fence, you can alter individual sections to wildlife friendly standards to create crossings and easier passage.



Scott Nicolaisen

Remedies for Existing Fence

Maintenance:

- Keep wires tight. Sagging wires and neglected fences create a hazard for both domestic animals and wildlife. Loose wires can snare animals as they attempt to cross; tight wires reduce the chance of entanglement.

Modifications:

- Replace barbed wire with smooth wire, particularly for top and bottom strands. Smooth wire reduces the chance of animals getting snared on barbs and fatally entangled.
- Adjust the height of the top wire: preferably no more than 40" and a maximum of 42" above the ground.
- Increase the distance between the top two wires to 12" to reduce entanglements.

- Reduce the number of wires to three, or at most four.
- Add a top rail, high-visibility top wire, a PVC cover on the top wire, or flagging to increase visibility and prevent collision or entanglement.
- Raise the bottom wire to at least 16" and preferably 18" above the ground to allow animals to slip under.
- In selected fence sections, raise the bottom wire to the level of the third wire and secure with a staple lock.
- For pronghorn, gather bottom wires in a PVC pipe to create a "goat bar" underpass.
- Add wildlife crossings where wildlife trails cross fences by using dropped wires, dropped rails, lay-down fence, or underpasses, as described earlier.
- When livestock aren't present, secure gates open to allow free passage for wildlife.

- Provide wildlife access to rivers, streams, wetlands, and water holes, and through seasonal migration areas.

Removal:

- Remove old fences that are in disrepair or no longer in use. Remove any unnecessary interior fences.
- Bale and carry away piles of wire. Some recycling centers will recycle old wire. Never leave wire on the ground.
- Many volunteer groups are interested in helping with fence removal projects to help wildlife, such as local chapters of sportsman's groups, scout troops, 4-H, and others.

Remedies for Existing Fences



Christine Paige

3-Dimensional Buck Fence

Buck and rail (also called jackleg) or buck and wire fence designs should be avoided as they create a formidable barrier and hazard to wildlife. Any 3-dimensional design is especially hard to leap over or crawl through, and animals can tumble and break legs. Often, these fences are built too high, too wide, and with rails or wires placed too closely together for animals to negotiate easily.

Three-dimensional buck and barbed wire fence creates a particular entanglement hazard. If buck and rail is also combined with woven wire or barbed wire, or the fence is placed on steep terrain, it presents a complete barrier to wildlife.

Buck or jackleg fence also requires high maintenance: the wooden bucks and rails rot and collapse under snow loads and winds, and long stretches of wire may be pulled down by wildlife.

Some landowners like the look of buck and rail because it evokes tradition and history. However, buck fence should only be used for very short reaches and specific situations, such as wet or very rocky soils. Frequent crossings should be provided for wildlife.

Modifications for Buck and Rail Fence

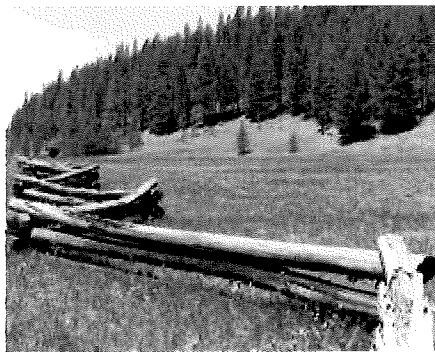
- Place the top rail no higher than 40" and preferably lower.
- Allow a minimum of 18" between the bottom rail and the ground.
- Allow a gap of at least 18" between rails.
- Eliminate the horizontal rub rail in several sections or completely. It is not needed for fence stability, and wildlife can negotiate the fence more easily.
- Never add woven wire or barbed wire to the fence.
- Create frequent crossings for wildlife by dropping one end of the top rail to the ground, or using a section with two rails at 18" and 36".

Worm Fence

Worm fences, also called zigzag or snake fences, were used by early settlers because they are easy to construct and require no posts. Worm fences are still popular in some areas for their rustic nature, especially as boundary fences. They are not used to contain large livestock.

Although worm fences are more easily negotiated by wildlife than three-dimensional jackleg or buck and rail fences, they can still be a barrier to fawns, calves, and other animals. Other drawbacks include rotting, the excessive number of rails needed, the considerable space the fence takes up on the ground, and maintenance.

Worm fence is simply constructed of rails stacked alternately on top of one another, with the rails interlocked like laced fingers where the ends meet. The fence zigzags to give it stability, and



Christine Paige

A low worm fence is easily hopped by most ungulates. Drop the top rail to the ground every few hundred feet to allow smaller animals to cross.

it can be used where posts can't be driven into the ground. These fences are usually only 2' to 3' high, and are most often used in areas where local timber is readily available and the terrain tends to be rocky and uneven. If you use a worm fence, create openings for wildlife to cross by intermittently dropping rails to the ground.

Worm Fence

- Use three to four stacked rails per section, 8' to 11' long.
- Logs or split rails can be used. Rails split in a triangular manner add stability.
- Set the ends of each bottom rail on a rock or short log slightly above the ground to postpone decay.
- Interlace the rails at joints at a 30-degree angle.
- Stack rails only up to 2' to 3' high.
- If extra stability is needed, fasten rails together with 6" nails or spikes, and drive 4' lengths of ½" rebar into the ground on either side of the joint, flush with the top rail.
- Drop rails to the ground every 400', and in swales and at stream crossings for easy wildlife passage.



Remedies for Existing Fences

Wildlife "Death Pipes"

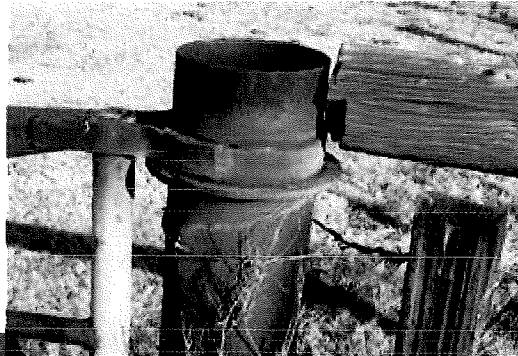
Open vertical pipes are silent and overlooked killers of birds and small animals. Hollow metal and plastic (PVC) pipes serve a wide variety of purposes, from ventilation pipes for buildings, outhouses, or irrigation systems, to fence posts, corner posts, gate uprights, and mining claim markers.

Birds, small mammals, and reptiles will investigate hollow pipes, especially for potential nest sites. Once inside they become fatally trapped, unable to find purchase on the pipe's smooth walls. In 2009, for example, a biologist at the Audubon California Kern River Preserve found more than 200 dead birds in a fallen 50-year-old irrigation standpipe.

Most victims were cavity-nesting birds, such as bluebirds, woodpeckers, kestrels, and small owls. Because open pipes are so prevalent across our landscapes, the overall toll on birds and small animals may be in the millions.

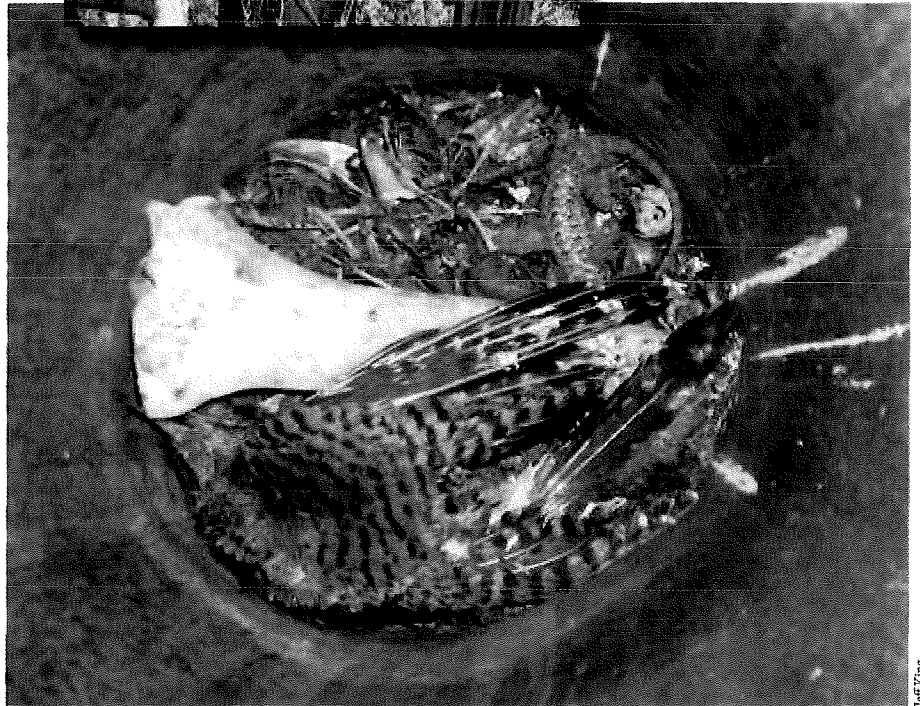
Easy Fixes for Death Pipes

- Remove unused obsolete pipes.
- Permanently cap or fill pipes used as fence posts, gate uprights, sign posts, claim markers, or monuments. These can be capped with concrete, or entirely filled with sand, gravel or concrete. Chain link fence posts can be capped with commercial caps.
- Cover ventilation pipes on buildings, irrigation systems, and outhouses with galvanized hardware cloth held in place by steel pipe clamps, or install commercial vent caps.



Sean Rowe

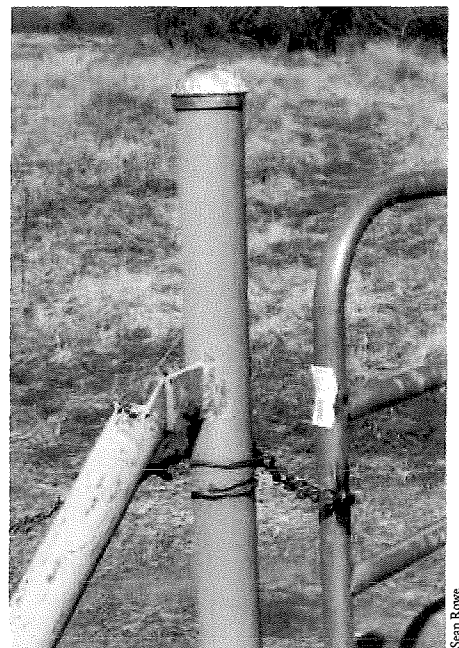
CAPPING OR SCREENING
OPEN VERTICAL PIPES
PREVENTS BIRDS AND
OTHER SMALL ANIMALS
FROM BECOMING
FATALLY TRAPPED.



Jeff King



Sean Rowe



Sean Rowe



Residential Fences

Fences serve many functions around homes, both aesthetic and practical: they may define a boundary, create a play space, contain pets, or discourage wildlife from yards and gardens.

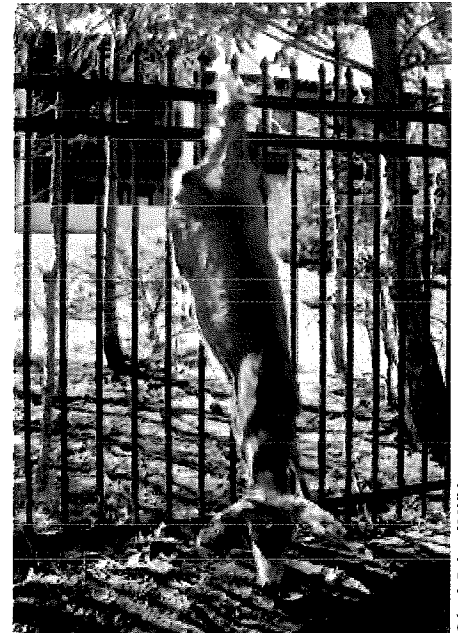
Avoid fences with spikes, pickets, or barbs that protrude above the top bar. Many wrought iron fence designs have decorative spikes on top. Gauging a jump by the uppermost horizontal bar, animals can misjudge the fence height and be lethally caught or impaled on the fence.

Any tall residential fence, whether wrought iron, plank, picket, or chain-link, should be used only for small areas

around the home, and not for larger perimeter fences. If a fence provides a complete barrier, an open gate may allow animals to find a way in but not out. Be sure vertical planks or bars are spaced closely enough that animals will not try to push through and become trapped. Check city and county ordinances for fence regulations.

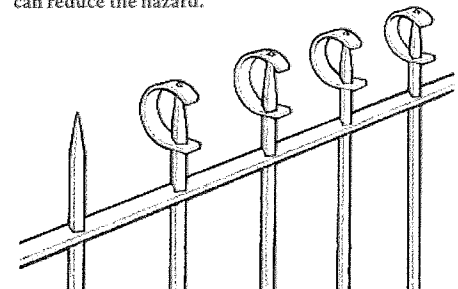
Many residential areas are in wildlife winter range. Using landscaping instead of fencing, or using only low, very permeable fences, allows wildlife to move freely through neighborhoods.

Photos below: Low, decorative yard fences pose little hazard or barrier to wildlife.



Colorado Parks and Wildlife

Iron fences with spikes or pickets are a lethal hazard for deer and other ungulates that wander neighborhoods. Cutting off or covering the spikes can reduce the hazard.



International Chimney Corporation created customized deer shields to modify a historic iron spiked fence for a client.



Christine Paige



Christine Paige



Christine Paige

A solid top rail and narrow vertical bars on this iron fence reduce hazards to wildlife.



Fence Alternatives

Fence Alternatives

Hedgerows

If you do not need a fence to contain or exclude livestock, consider other creative ways to define boundaries and discourage trespass.

A line of shrubs or trees can mark a boundary line, beautify your landscape, and provide nest sites for birds and food and cover for wildlife. Depending on the site, a wide range of native and ornamental shrub species can be used to create an effective hedgerow – from lilacs and honeysuckle to willows, alder, and big sagebrush. Your County Cooperative Extension Office can help find local sources for plants and choose appropriate species for your site.

Many native shrubs are suitable for hedges and enhance wildlife habitat.

Beware using some non-native species that can become difficult or impossible to manage.



Mix it up: consider using several species, varying the width of the hedgerow, or using plants of different heights to create a natural and wildlife friendly hedge. Once established, hedgerows require minimal maintenance unless you want a highly manicured look.



Christine Paige

Boundary Markers

Where you do not need a fence, consider marking property boundaries with signs, flexible fiberglass or plastic boundary posts, or fence posts spaced at intervals but without cross wires.

Property boundaries can also be marked with steel t-posts or flexible fiberglass or plastic posts such as Carsonite (www.carsonite.com) or Flexstake posts (www.flexstake.com), available through survey and forestry suppliers. Commercial fiberglass and plastic marker posts are highly visible and durable. However, the cost per post can be greater than a heavy-duty steel fencing t-post.

Posts can mark a boundary where fences are not needed. Flexible plastic posts can be ordered with reflective tape or custom lettering.

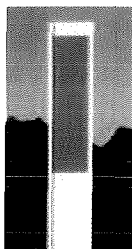
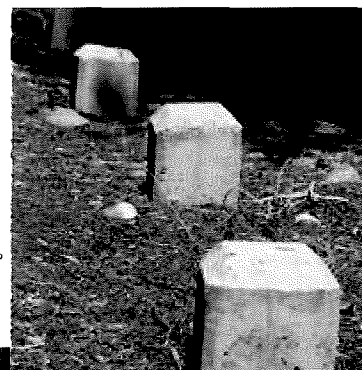


Photo courtesy of Carsonite Composites

Barrier Posts

Barrier posts or bollards are short, stout posts spaced to prevent access by vehicles. They can be used to define a driveway or parking area, or edge an expanse of lawn. Posts can be spaced closely together, or placed farther apart and connected with a heavy chain, cable or rail, from two to three feet high. Bollards and posts with low chains or rails pose little deterrent or hazard for wildlife.

Bollards can be made of wood, concrete, brick, stone, cast iron, aluminum, or steel; a row of boulders serves the same function. Some can be installed as fixed or removable posts. A wide variety of bollard designs and ornamental covers are also available commercially.



Christine Paige



Christine Paige

A row of boulders or bollards (concrete or wooden posts) can prevent vehicle access but poses no barrier to wildlife.

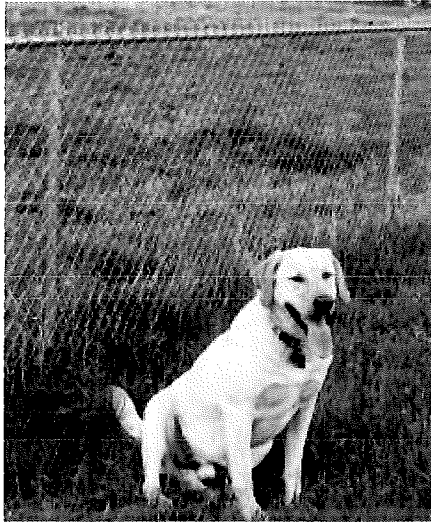


If You Must Exclude

There are times when it is necessary to use exclusion fence to keep wildlife out.

If you must put up an exclusion fence, avoid fencing a large area that includes wildlife habitat. Focus exclusion fences on small areas for specific purposes, such as fencing around play areas, vegetable gardens, beehives, calving and lambing areas, or haystacks. Keep exclusion fence close to the activity you need protected, and allow wildlife to use other parts of the property.

For any exclusion fence, place gates at corners: an animal that inadvertently finds itself trapped inside is more likely to find escape through an open corner gate than through a side gate.



Christine Paige

Use chainlink fences only for specific purposes, such as play areas and dog kennels.

Wooden Plank Fence and Chainlink Fence

Chainlink fences and wooden fences with closely spaced vertical planks are especially unfriendly to wildlife and can create a complete barrier to animals of all sizes, from turtles to moose. If you must use chainlink or plank fences, limit their use to small enclosures.

Yard fences and play area fences often do not need to be more than 4' high. If higher, be sure gates are kept secured to prevent animals from finding their way in.

For small chainlink dog kennels, attach a roof to prevent wild animals from becoming trapped inside. A roof also provides shade and shelter for your pets.



Christine Paige

Deer and Elk Exclusion Fence

A permanent non-electric exclusion fence for deer and elk should be 7' to 8' high. A 7' to 8' wooden fence that animals can't see through is typically used around housing areas. For gardens, vineyards, and other agricultural plots, 8' woven wire fence is more often used with posts set at 8' to 20' intervals, and the wire is brought tight to the ground. Make the top highly visible by using a top rail, high-visibility wire, or flagging. Place gates at corners, where an accidentally trapped animal is more likely to find an escape.

A 7' to 8' fence is an effective barrier to elk, but should be used only for specific needs, such as gardens or haystack yards. Make the top highly visible with flagging, white tape or wire, or a rail.



If You Must Exclude

Haystacks and Hay Yards

Several options exist for protecting haystacks from wildlife damage. These include electric, non-electric, temporary, and permanent designs.



Montana Fish, Wildlife & Parks

Deer-D-Fence

A traditional 8' woven wire fence can protect a stackyard from game damage. An alternative is a permanent 7-strand electric fence.

Temporary Solutions

A simple and cost-effective solution is to wrap haystacks with heavy-duty plastic mesh netting, such as Deer-D-Fence (www.tizergardens.com/distributing.html), a 2x2" durable plastic mesh that is strong, lightweight, and easy to handle. Haystacks and large bales can be wrapped quickly, and the netting is readily lifted off when not needed. This netting is especially useful for temporary applications, rapid installation, and remote settings.

Plastic netting can also be used instead of woven wire as fencing, and installed on wood or steel posts using UV-resistant zip-ties. The plastic is UV-resistant and durable, and materials cost is comparable to woven wire. However, labor costs for fence construction can be greater than with traditional materials.

Increase visibility by adding poly-coated wire, tape, or flagging when using plastic mesh as fencing. Although the mesh would cause little harm to most

large animals, it is nearly invisible when erected and should be flagged to be visible to birds.

Permanent Fences

Many landowners prefer to protect a large haystack yard with a permanent fence. The traditional stackyard fence is at least 8' high and uses woven wire with wood posts or a combination of wood and steel posts. One-way gates should be placed in the corners to allow animals that might be inadvertently trapped inside to find a way out more easily.

A permanent electric fence, 6' to 7' high, is also effective for protecting stackyards from game damage. This fence is constructed with high-tensile smooth wire spaced at 10" intervals with alternating hot and grounded wires.

A 7-wire fence 72" high with strands at 10" intervals is adequate for elk. Deer, on the other hand, require a higher fence of 84", with 8 to 9 wires.



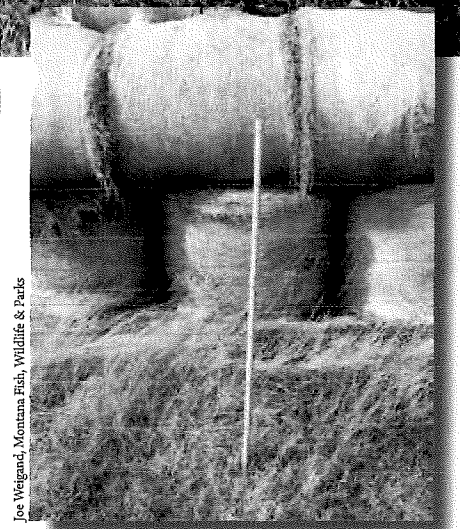
Christine Page



Larry Feight, High Country Ag. Marketing

Haystack Fence

- Use 10' pressure-treated wooden line posts, 3" to 4" in diameter, driven 2.5' into the ground, and spaced at 30' intervals.
- Use 10' pressure-treated wooden brace posts, 4" to 5" in diameter, driven 3' into the ground.
- Use 12.5-gauge, smooth Class III galvanized wire with a tensile strength of 170,000 PSI and breaking strength of 1,308 lbs. To increase visibility, use white poly-coated wire with the same specifications.
- Space seven strands at 10" intervals; the top wire at 72" for elk or 84" for deer; wooden posts require using insulators.
- Alternate hot and ground wires: bottom wire is grounded and top two wires are hot.
- Place solar energizer according to manufacturer recommendations.
- Ground fence properly according to the energizer instructions.
- Install electric fence warning signs.



Joe Weigand, Montana Fish, Wildlife & Parks

A permanent electric fence is an effective alternative to woven wire fence. A 6' fence with 7 strands at 10" intervals is adequate for elk.



If You Must Exclude

3-D Deer Fence for Yards and Gardens

Deer are not comfortable jumping fences with both height and depth, and are wary of fences that are not flat and regular. A **staggered picket fence or leaning fence can be an effective deer deterrent**. Another is to add tall vegetation – tall perennials, shrubs and trees – along a fence to increase the perceived depth of the barrier.

Another alternative is a 3-D electric deer fence, which can be effective for keeping white-tailed deer out of orchards and vegetable gardens. This fence is

3-D Deer Fence

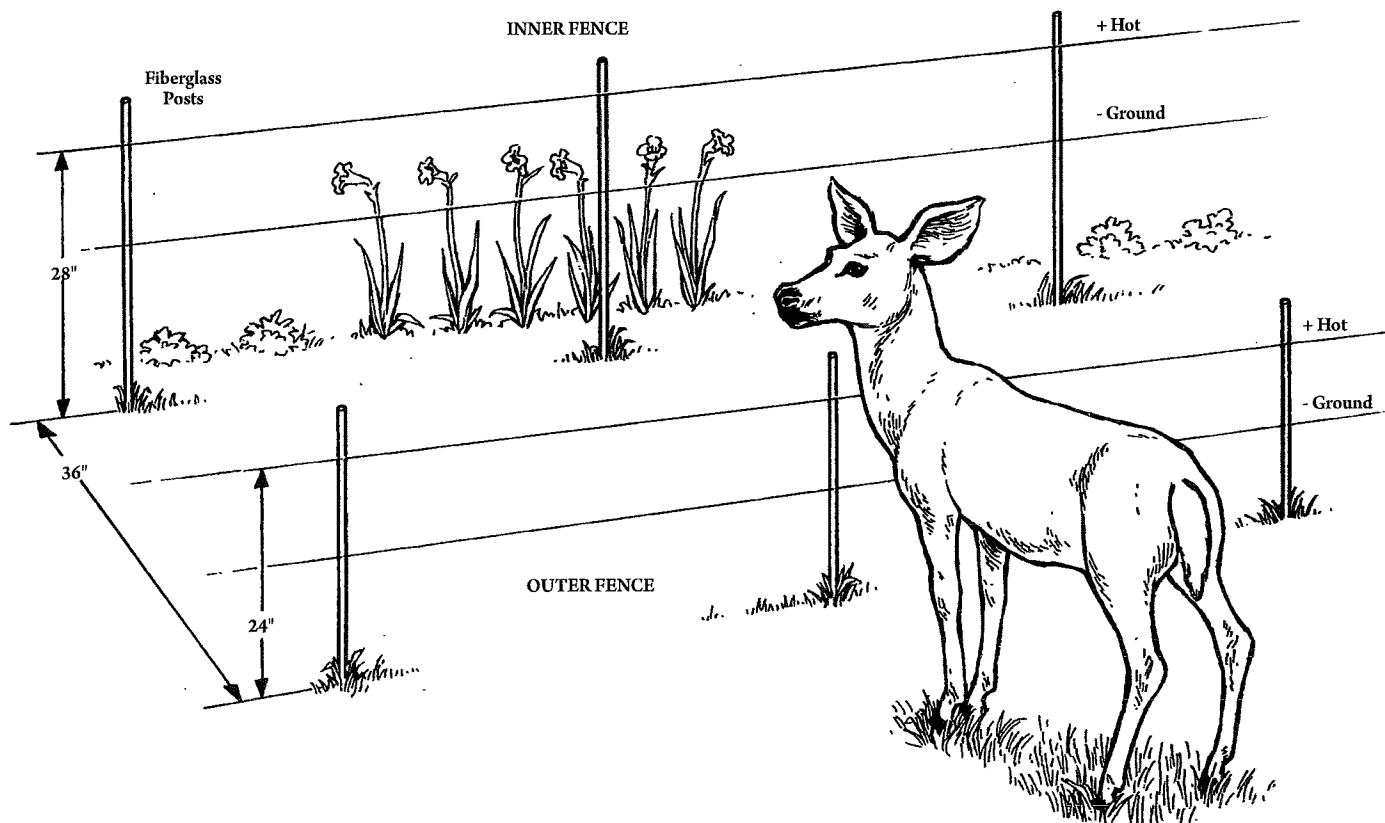
- Place two separate lines of 4' fiberglass posts, the lines spaced 36" to 38" apart. Drive posts 16" to 18" into the ground.
- On the inner fence, string two 12.5-gauge high-tensile smooth wires at 12" and 28" above the ground.

- On the outer fence, place two wires at 12" and 24" above the ground.
- Make sure there is at least a 12' clearing in front of the outer fence so deer will see the fence. Flagging or high-visibility wire also help both deer and people see the fence.
- Install a solar energizer according to manufacturer's instructions.

basically two parallel fences only 36" to 38" apart, the outside slightly shorter than the inside fence. The 3-D fence can be constructed as a permanent fence with

high-tensile wire or as a temporary fence with poly-rope or tape and moveable posts.

3-D ELECTRIC DEER FENCE FOR YARDS AND GARDENS



Deterring Large Predators



Deterring Large Predators

Many different permanent and temporary electric fence designs can deter large predators. These fences are used primarily for small-scale operations, such as beehives, dumpsters, lambing or calving areas, corrals, bone piles, and other small areas in need of protection from scavenging or predation.

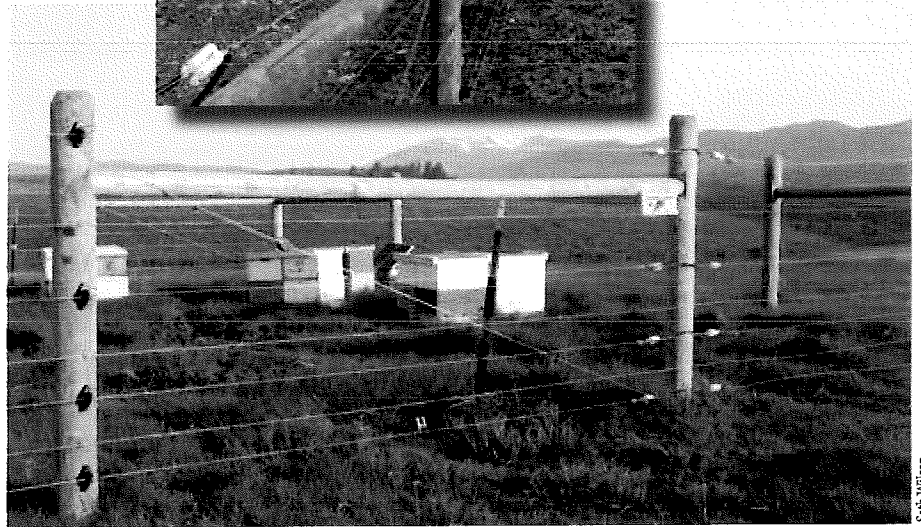
A 7-wire permanent electric fence from 42" to 54" high is most commonly used to deter bears and wolves. In special situations, a higher 9-wire or 11-wire fence might be used. In dry, rocky soils, the fence should have alternating charged and grounded wires, with both top and bottom wires hot. In this setup, an animal must touch both a hot and a ground wire to receive a full shock. Use a grounded bottom wire if the wire is likely to touch vegetation. A fence with all hot wires can be used in areas with damp or moist soil that will provide sufficient grounding when the animal touches a hot wire.

The table at right shows specifications developed by the NRCS in cooperation with Montana Fish, Wildlife & Parks (NRCS 2006b). *(continued)*



Seth Wilson

Predator deterrent fencing should be used only around specific areas, such as corrals and beehives. Always hang warning signs on electric fences.



Seth Wilson

Bear and Wolf Deterrent Fencing

(Adapted from NRCS 2006B)

Charge and Recommended Wire Heights from Ground Level

	Bear ¹ 7-wire	Bear & Wolf ² 7-wire	Beehive or Chicken Coop ³ 7-wire	Wolf & Bear ⁴ 9-wire (corral or home areas)	Wolf & Bear ⁴ 11-wire (away from corral or home areas)
Top wire	(+) 42"	(+) 54"	(+) 54"	(+) 60"	(+) 72"
2nd wire	(-) 36"	(-) 42"	(-) 42"	(-) 50"	(-) 64"
3rd wire	(+) 30"	(+) 32"	(+) 32"	(+) 42"	(+) 56"
4th wire	(-) 24"	(-) 24"	(-) 24"	(-) 36"	(-) 48"
5th wire	(+) 18"	(+) 18 "	(+) 18 "	(+) 30"	(+) 40"
6th wire	(-) 12"	(-) 12"	(-) 12"	(-) 24"	(-) 32"
7th wire	(+) 6"	(+) 6"	(+) 6"	(+) 18"	(+) 26"
8th wire				(-) 12"	(-) 20"
9th wire				(+) 6"	(+) 15"
10th wire					(-) 10"
11th wire					(+) 6"

Bear¹ (42") 7-wire: Primary use is to deter grizzly and black bears; allows deer and elk passage.

Bear & Wolf² (54") 7-wire: Primary use is to deter grizzlies, black bears, and wolves from calving and lambing areas, but where wolf activity is low to moderate or there is potential for wolf activity.

Beehive or Chicken Coop³ (54") 7-wire: Primary use is to deter grizzly and black bears from apiaries.

Wolf & Bear⁴ (60-72") 9- or 11-wire: Primary use is to deter wolves and bears when predator activity or risk is high. Also useful for situations where ungulate damage to a lower fence (54") might be anticipated, or there is a predator issue.



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Deterring Large Predators



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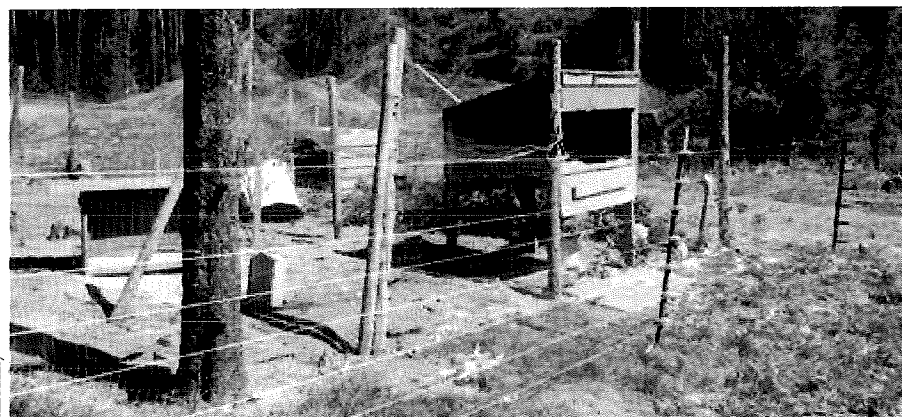
Deterring Large Predators

(continued)

Key to the success of electric fences is to erect them before the attractant level is high, so that animals are “trained” to a fence early on. **Also, the amount of energy your setup can deliver over the full distance of the fence is crucial.** Because of predators’ thick fur, the system must deliver enough shock to deter them. For grizzlies, the system should deliver 6,000 volts or more, and will require an energizer with a rating of at least 0.7 joules. Be sure your energizer can deliver adequate power over the distance you need. Vegetation touching the wires and other factors can cause

energy drain. Regularly check the voltage on every hot wire with a high-quality voltage tester, especially midway and at the farthest distance from the energizer. In addition, always install warning signs on the fence.

For more complete instructions and appropriate designs, see *Bears and Electric Fencing* published by Montana Fish, Wildlife & Parks, available online at <http://fwp.mt.gov/fishAndWildlife/livingWithWildlife/beBearAware/bearAwareTools.html> (Annis 2010). Also see *Practical Electric Fencing Resource Guide: Controlling Predators* published by the Living with Wildlife Foundation and available online at <http://www.lwwf.org> (Thompson, et al. 2005).



Tim Manley

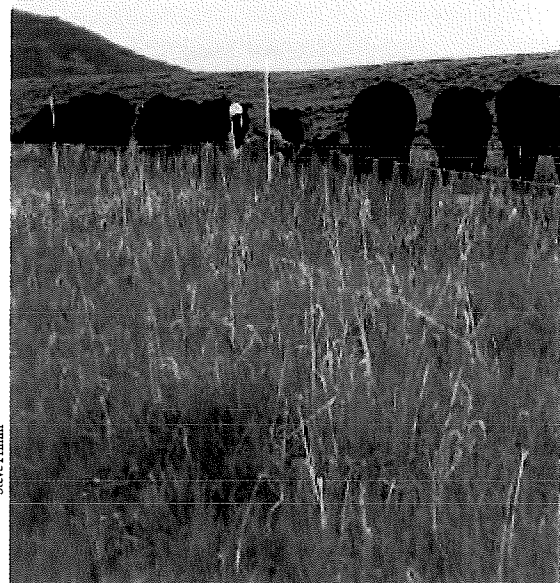
Chicken coops and beehives can be irresistible to bears, but a high-energy electric fence is effective protection.

Fladry to Deter Wolves

Fladry is a line of wire strung with long flags or streamers used to deter predators from livestock. Fladry’s advantage is that it is portable, temporary, and requires comparatively little planning. It serves best as a short term deterrent until a more permanent fence can be planned and installed.



Steve Primm

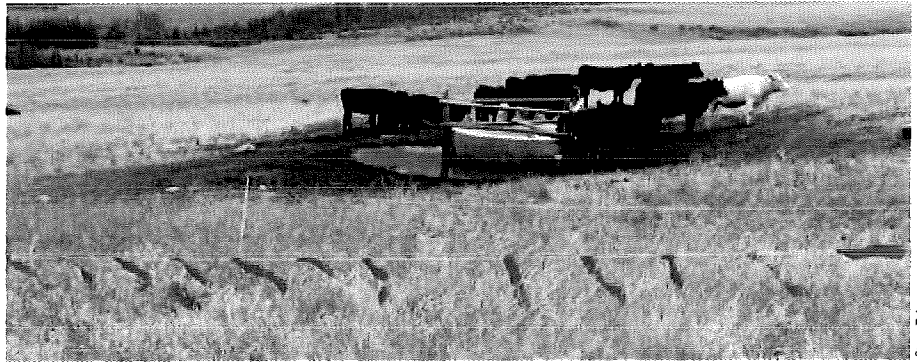


Steve Primm

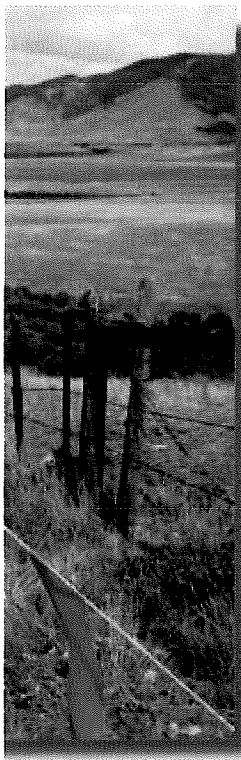
Detering Large Predators



© Henry H. Holdsworth/wildbynaturegallery.com



Steve Primm



Deployed around temporary pastures, fladry has been shown to deter wolves for up to 60 days, and much longer if electrified. Be aware that this technique can have considerable problems with deployment, tangling, power drain, general availability, and high initial capital and labor costs. However, because it is portable and temporary, a number of western ranchers have found it to be an effective tool to protect livestock from wolves (Primm and Robinson 2011).

Fladry

- Use a large spool or reel (6" minimum diameter and 11" minimum width) to coil and deploy fladry. Handling by hand is enormously time-consuming.
- Electrified fladry ("turbo fladry") has a longer period of effectiveness, and deters livestock from trampling the line.
- Use $\frac{3}{8}$ " x 4' fiberglass rod posts. Tip: Carry these in an old golf bag to deploy in the field.
- Line height should be no higher than 28," and fladry flags should hang above the ground. In spring and summer it is difficult to keep flags from touching vegetation.
- To secure the line, use a "harp clip," which allows the fladry flags to slide through the clip. See <http://www.premier1supplies.com> for an effective harp clip.
- For anchor posts, use thicker composite posts with wire clips, steel t-posts with insulators, or insulators on permanent wooden posts of existing fence.
- Create gates using anchor posts and good quality electric fence handles connected to an eye-bolt on the post.
- Electrify with an energizer that will provide an output of at least one joule per mile of fladry.
- A "wide impedance" energizer will deliver more consistent voltage under adverse conditions, such as dry soils, dry snow, cold temperatures, and long insulating fur.





Getting Help

Getting Help

Montana Fish, Wildlife & Parks Private Land Technical Assistance Program can contribute information, technical assistance, staff support, and sometimes cost-share to projects that reduce conflicts with wildlife and enhance wildlife habitat on private lands. Other FWP game damage and habitat enhancement programs may also be avenues to find support for wildlife friendly projects. Contact FWP Wildlife Bureau at (406) 444-3065 or your local FWP field office.

The Natural Resources Conservation Service (NRCS) offers cooperative programs to address natural resource concerns, including improvements to wildlife habitat. NRCS can provide technical and financial assistance for many types of enhancement projects, including wildlife friendly fence construction and modification. The NRCS works on a voluntary basis with private landowners. See www.mt.nrcs.usda.gov to learn more about their programs and contact information for your local NRCS Field Office.

The Montana Department of Transportation works cooperatively with landowners to construct or modify fences along state highway right-of-ways to wildlife friendly standards. Contact MDT Environmental Services for more information at (406) 444-7228.

In addition, check with your local County Cooperative Extension Office for technical assistance and information on landowner programs. If you share a boundary with federal lands or lease a federal grazing allotment, contact the agency's local office to inquire about opportunities for cooperative projects to replace or modify fences to be wildlife friendly.

Many sportsmen's clubs, civic groups, or conservation organizations may also be interested in helping to provide either cost-share support or volunteers for wildlife friendly fencing projects to enhance wildlife habitat.



Scott Nicolaren



Mark Goele

Many land trusts, sportsmen's clubs, community groups, and conservation organizations may be able to help with technical assistance, staff support, and small grants on wildlife friendly projects.



Bert Linder

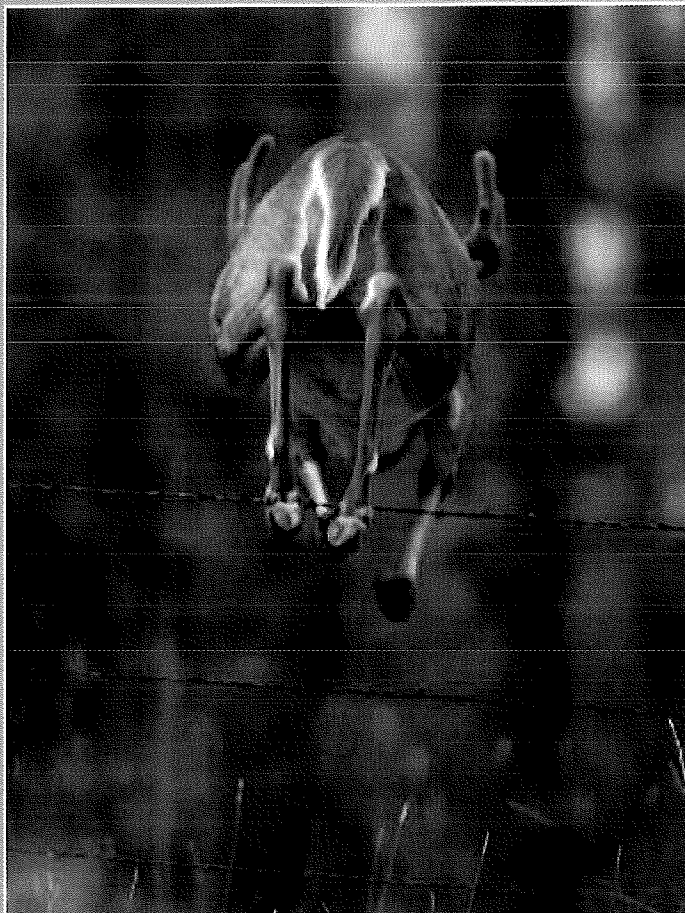


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For more information or assistance, contact your
local FWP office, wildlife biologist, or warden.

Joe Weigand, Private Land Wildlife Specialist,
can also be reached at (406) 444-3065, or email joweigand@mt.gov.



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Wildlife & Parks**

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California Building Energy Efficiency Standards

Title 24 guidelines for controlled lighting

REV 06.09.2016



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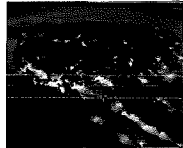
Title 24 Guidelines for Controlled Lighting



Title 24 Guidelines for Controlled Lighting

On July 1, 2014, California Title 24 (T24) Building Energy Efficiency Standards went into effect. The lighting and lighting controls sections were expanded clarifying the mandatory requirements for residential and nonresidential buildings that include outdoor spaces. In keeping with the California legislation, the standards must be cost effective and include approaches that account for equipment improvements in efficient technology. As one will see, the newer technologies delivering higher energy savings are favored in the code. The new efficiency standards focus on lighting controls and LED luminaires, both of which offer the greatest energy savings with control capabilities.

California Energy Commission estimated reduction benefits from code compliance:



Annual energy savings

- 613 gigawatt-hours
- 195 megawatts peak demand



Resulting air quality and emission reductions per year

- 215 metric tons carbon dioxide equivalent
- 2.4 tons sulfur oxides
- 41 tons carbon monoxide
- 59 tons nitric oxide

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While this training material was developed based upon the published Building Energy Efficiency Standards for Residential and Nonresidential Buildings (CEC-400-201-004-CMF-REV2), Residential Compliance Manual for the 2013 Building Energy Efficiency Standards (CEC-400-2013-001-CMF), and Nonresidential Compliance Manual for Building Energy Efficiency Standards (CEC-400-2013-002-CMF) (collectively, "the code"); it is not intended to replace the code and experts that interpret the code. This training material is based on the code as it exists at the time of publication, and the code may be updated without notice. Eaton accepts no liability for the content of this presentation, or the consequences of any action taken on the basis of the information provided.

HOWTO USE THIS GUIDE

This guide is constructed to simplify the aggressive and complex California Energy Code of Title 24 into three basic steps covering the requirements for the most common spaces found in both Residential and Nonresidential compliance. Icons are used to describe the luminaire and control requirements that are conveniently aligned with Eaton's broad range of luminaires and controls delivering a compliant Title 24 space.

Sample page from this guidebook shown below:

Identify Your Space

Simplification begins by separating a building into spaces such as "office" and outlining the conditions of the space to walk through Title 24 requirements. Space assumptions and energy budget requirements are located in the header area while the rest of the page details specific luminaire and control combinations to make the space Title 24 compliant.

Follow the 3 steps below to ensure your space meets Title 24:

1. Analyze

Four simple mandatory lighting control elements cover the changing components of Title 24. The space defined above is analyzed against the code, notes are provided, and exceptions to the spaces are shown. The far right shows the code references to facilitate further understanding.

2. Align

Icons are presented to visually align the specific requirements that satisfy Title 24 requirements. The code may offer options or combined functions to satisfy the requirements.

3. Select Products

The final step is selecting products that align with the requirements. The California Title 20 Appliance Database provides a list of certified products for select product categories such as self-contained dimmers, Metal Halide luminaires, emergency EXIT signs, residential LED luminaires, etc. Not all products must be certified.

NONRESIDENTIAL INDOOR: Medium or Large Office Title 24 Requirements

SPACE ASSUMPTIONS

- Space
- Electrical Load
- Daylighting

Building

LED Lighting Power Density 0.75 watts per square foot required for Area Category Method

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting
- Exception when space level control not required:
 - Up to 0.2 W/ft² of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel

Manually Switched ON/OFF

MULTI-LEVEL LIGHTING

- Luminaires must provide uniform dimming
- Capable of reducing power by at least one of four control functions
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Manual Dimmer + Lumen Maintenance Control + Tuning Control + Daylighting Control + Demand Response

(OPTIONAL)

SHUTOFF CONTROL

- Luminaires turned off when vacant
- 120V receptacles only having one controlled receptacle within 6 ft of uncontrolled receptacle
- Separate shut-off control for each 5,000 sq ft
- Automatic Time Switch control must have an override to remain on no more than 2 hours

- Exceptions to shutoff control include:
- Lighting serving a continuous use area
- Emergency egress up to 0.05 watts per sq ft

Occupancy Sensor + Manual On/ Auto Off + Remote Signal Control + Automatic Time Switch + Receptacle Control

(CHOOSE ONE OR MORE)

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present
- Exceptions when daylighting control not required:
 - Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W

Luminaire Dimming + Daylighting Control

Reference: See 130.1(a) page 140

Reference: See 130.1(a) & b) page 140

Reference: See 130.1(c) page 141, 130.5(d) pages 151-152

Reference: See 130.1(d) page 143



Select appropriate product solutions from the Product Reference Guides located after the Nonresidential and Residential sections.

Eaton offers a broad range of controlled lighting solutions to satisfy the latest in Title 24 code compliance that are both certified to the California Title 20 Appliance database when required and when certification is not required.

Note: Title 20 certified products can be found at <https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx>

References provide specific page numbers to the code specifications found in the California Energy Commission Building Energy Efficiency Standards. This 245 page document can be found at www.energy.ca.gov/title24

TITLE 24 ICONOGRAPHY

Iconography System

The icons symbolize specific language found in the code requirements. They represent product and space characteristics. Icons not only represent the requirements but attributes Eaton products provide. This simplifies educating one on the code, how to apply the code for a given space, and select the products that will deliver a Title 24 compliant space.

LUMINAIRES / CONTROLS				
 Luminaire Dimming	 Fluorescent Luminaire w/ Ballast	 LED Luminaire	 Metal Halide Luminaire	 Exit Luminaire
 Residential Recessed Luminaires w/ Ballast	 Emergency Back-up (For Egress)	 High Efficacy		
FUNCTIONAL REQUIREMENTS				
 Daylighting Control	 Vacancy Sensor Manual On/Auto Off	 Occupancy Sensor	 Demand Response	 Manually Switched ON/OFF
 Manual Dimmer	 Lumen Maintenance Control	 Tuning Control	 Automatic Time Switch (Indoor)	 Astronomical Time Switch (Outdoor)
 Photocontrol	 Remote Signal Control	 Captive Key-Card Control	 Combined HVAC & Lighting Control	 Part-night Outdoor Lighting Control
 Receptacle Control	 Reporting	 Monitoring	 Automatic Countdown Timer Switch	
CONSTRAINTS				
 Square Footage Range	 Maximum Wattage Controlled Together	 Daylight Opening	 BUG / Zonal Lumen Requirements	 Lighting Power Density
 Height of Luminaire for Outdoor	 24/7 Operation			

ICONOGRAPHY GUIDE: Luminaires and Controls



High Efficacy

For the purpose of Title 24 compliance in residential projects a luminaire can be certified as High Efficacy by meeting performance requirements. High efficacy luminaires differ by technology. Some examples are: LED luminaires must meet Joint Appendix 8 (JA8) and certified to California Title 20 Appliance Database, CFL residential recessed luminaires must contain CFL ballast that are certified to California Title 20 Appliance Database meeting select efficacy requirement, and residential fluorescent luminaires containing fluorescent ballasts that are certified to California Title 20 Appliance Database.

References: Tables 150.0-A, 150.0-B; Sections 100.0(h), 110.9(e), 110.10(b), 130.1(c), 150.0(k), 150.2(b), 110.9(f)



LED Luminaire

In order for residential LED luminaires to be classified as High Efficacy they must meet Joint Appendix 8 (JA8) and be certified to the California Title 20 Appliance Database. Residential compliance includes single family homes, hotel/motel guest rooms, high-rise apartment living spaces, dormitory rooms, senior living facility quarters, etc.; all of which are considered generically "dwelling" spaces.

References: Tables 150.0-A and 150.0-B; Section 150.0(k), 150.2(b), 110.9(e), 100.0(h)



Fluorescent Luminaire w/ Ballast

In Title 24 Residential and Nonresidential compliance, fluorescent luminaires must include ballasts that are certified to the California Title 20 Appliance Database. While 4-pin electronic fluorescent is generally viewed as a compliant device, the ballast installed must be certified to the California Title 20 Appliance Database. In order to be certified, the ballast must meet all Title 20 requirements.

References: Tables 130.1-A, 150.0-A; Sections 100.0(h), 110.1



Residential Recessed Luminaires w/ Ballast

Fluorescent ballasts certified to the California Title 20 Appliance Database for use within a residential recessed luminaire would be classified as High Efficacy. Requirements to use high-efficacy devices are found in single family homes, hotel/motel guest rooms, high-rise apartment living spaces, dormitory rooms, senior living facility quarters, etc.; all of which are considered "dwellings".

References: Table 150.0-A, 150.0-B; Sections 100.0(h), 110.1, 110.9(f)



Luminaire Dimming

Title 24 Nonresidential indoor compliances utilize dimming luminaires for requirements such as demand response, multi-level dimming and daylighting. Power adjustment factors that lower claimed LPD levels can be earned when select controls strategies are applied. Nonresidential outdoor compliance strategies utilize dimming luminaires during periods where the area is vacant. Part-night lighting control and centralized time-based zone control may also include dimming as part of an energy use reduction plan.

References: Tables 130.1-A and 140.6-A; Sections 130.1(b), 130.1(c), 130.1(d), 130.1(e), 130.2(c), 140.6(a)(2)



Exit Luminaire

Only Emergency Exits luminaires certified to the California Title 20 Appliance Database can be used for Title 24 compliance. This does not include egress luminaires but those that provide egress signage such as "EXIT", illuminated 24 hours a day and 365 days a year.

References: Sections 140.6(a), 140.8(b)



Emergency Back-up (For Egress)

Emergency back-up circuits are commonly used in the design of life safety systems such as lighting to meet the code requirements for safety and noted in Title 24 as low power consumption circuits shown on the design plans.

References: Sections 130.1(a), 130.1(c), 140.6(a), 140.6(c), 150.0(k)

ICONOGRAPHY GUIDE: Functional Requirements



Reporting

For use in commissioning, reports can be provided from the energy management system to demonstrate performance for lighting loads, electrical distribution system results, branch circuit measurements, control impact, demand response, daylighting performance, and show where adjustments were made. The ability to report results from commissioning are required for building owner for buildings over 10,000 square feet.

Reference: Sections 120.8(a), 120.8(i), 130.1(d), 130.1(e)



Monitoring

An Energy Management Systems (EMS) is a computerized control system designed to regulate the energy consumption of a building by controlling the operation of energy consuming systems, such as the heating, ventilation and air conditioning (HVAC), lighting, and water heating systems, and is capable of monitoring environmental and system loads, and adjusting HVAC operations in order to optimize energy usage and respond to demand response signals.

Reference: Sections 120.8(a), 120.8(i)



Vacancy Sensor Manual On/Auto Off

A manual ON with automatic off control, commonly called “vacancy sensors”, can be used to in lieu of occupancy sensors especially when short periods of occupancy occur and the lighting is not needed for the short period. Title 24 limits the amount of time a space is lit when a space is not occupied and requires in spaces like offices and conference rooms mandatory controls to turn off a the space when unoccupied.

References: Sections 110.9(a), 110.9(b), 110.10(b), 141.0(b), 150.0(k)



Daylighting Control

Title 24 in Nonresidential Indoor compliance mandates daylighting controls where there are skylit and sidelit zones. In the case of sidelit zones, where there are 24 square feet of glazing inside buildings and 36 square feet of openings or glazing for parking garages. Sidelit zones are separated in primary and secondary zones. Self-contained sensors must be certified to California Title 20 Appliance Database while daylighting systems must be certified by approved technicians.

References: Tables 141.0-E, 141.0-F; Sections 110.9(a), 110.9(b), 130.1(b), 130.1(d), 140.3(c), 140.6(d)



Demand Response

Title 24 requires that buildings larger than 10,000 square feet have demand responsive lighting controls capable of delivering a minimum of 15% reduction in lighting load in a uniform method. In the case of altered or remodeled spaces, the 10,000 square feet applies to the area modified.

References: Tables 130.1-A, 140.6-A, 141.0-E, 141.0-F; Sections 110.9(a), 110.10(b), 130.1(b), 130.1(e), 130.3(a), 140.6(a), 141.0(b),



Occupancy Sensor

The automatic on and off feature of the occupancy sensor adjusts the lighting load based upon the space's activity. Title 24 code deploys this functionality as mandatory reducing or turning off power in residential, nonresidential indoor and outdoor compliance requirements. It is also included to as a power adjustment factor to reduce installed lighting loads to meet the lighting power budgets.

References: Tables 140.6-A, 141.0-E, 141.0-F; Sections 110.9(a), 110.9(b), 130.1(c), 130.2(c), 130.5(d), 140.6(a), 141.0(b), 150.0(k)



Manual Dimmer

In nonresidential compliance, continuous dimming is required for certain luminaires such as LED, see TABLE 130.1-A; a manual dimmer is one method to satisfy requirements of 130.1(b). Manual dimmers are also a part of the power adjustment factor(PAF) offering that can reduce prescriptive lighting power densities(LPD). Residential compliance utilizes dimmers in some spaces when “low efficacy” luminaires are allowed.

References: Tables 130.1-A, 140.6-A, 141.0-E, 141.0-F; Sections 110.9(b), 130.1(a), 130.1(b), 130.3(a), 140.6(a), 141.0(b), 150.0(k)



Manually Switched ON/OFF

Title 24 requires that a manual switch control with ON/OFF be provided for each area enclosed by ceiling-height partitions. There are some exceptions including large areas including malls, sales floors, industrial facilities, and larger public restrooms. The manual switch must be accessible within the same room and lighting types such as general lighting and display lighting must be separately circuited. When other lighting controls are included such as a manual dimmer, the ON/OFF functionality cannot be bypassed.

References: Tables 141.0-E, 141.0-F; Sections 110.9(a), 110.9(b), 130.1(a), 130.1(b), 130.1(c), 141.0(b), 150.0(k)

ICONOGRAPHY GUIDE: Functional Requirements (continued)



Lumen

Maintenance Control

Lumen maintenance provides an initial lower power level by the luminaire corresponding to typical lumen depreciation factor. The power will increase over time up to the maximum rated wattage to accommodate the reduction in the light over time in the space. Lumen maintenance controls is one of the five function alternatives to meet Multi-level Lighting Controls requirements.

References: Section 130.1(b)



Tuning

Control

Tuning control provides an initial lower power level (controlled by authorized personnel only). The power can be increased over time up to the maximum rated wattage. Tuning controls is one of the five function alternatives to meet Multi-level Lighting Controls requirements.

References: Sections 130.1(b)



Receptacle Control

Under Title 24, electrical distribution systems deployed with 120V receptacles used in offices, lobbies, conference rooms, office space kitchenettes, copy rooms, hotel/motel guest rooms are required by Title 24 to automatically shut-OFF when space is considered unoccupied. They are required to be located six feet from an uncontrolled receptacle. Split wired duplex receptacles with one controlled are acceptable.

References: Sections 110.10(b), 130.5(d), 141.0(b)



Automatic Time Switch (Indoor)



Astronomical Time Switch (Outdoor)

Title 24 allows for an Automatic Time Switch that controls lighting based on the time of day and astronomical events such as sunset and sunrise, accounting for geographic location and calendar date to as one of the shutoff control functions to meet the requirements. Outdoor applications require the Automatic Time Switch to include Astronomical functionality.

References: Sections 110.9(a), 110.9(b), 130.1(c), 130.2(c), 130.3(a)



Captive Key-Card Control



Combined HVAC & Lighting Control

Title 24 allows the use of captive key-cards as one of the optional controls to automatically turn off the lighting and controlled receptacles and/or modify the HVAC setpoints reducing energy consumption upon vacancy. These are commonly used in hotel/motels control in which the key that activates the override cannot be released when the lights are in the on position.

References: Sections 120.2(e), 130.1(c), and 130.5(d)



Automatic Countdown Timer Switch

In Title 24 the use of a countdown timer switch control is limited to single-stall restrooms and closets less than 70 square feet with a maximum setting of 10 minutes or in server aisles in server rooms with a maximum setting of 30 minutes.

References: Sections 130.1(c)



Photocontrol

Common control device that senses sunlight and turn on the luminaires at dusk and turns off the luminaires upon sunrise.

References: Section 130.2(c), 130.3(a), 150.0(k)



Part-night Outdoor Lighting Control

These controls turn off or reduce the lighting power for a portion of the night in outdoor lighting applications such as auto dealerships and building facades.

References: Sections 110.9(a), 110.9(b), 130.2(c)



Remote Signal Control

Title 24 allows for a signal from another building system such as an Energy Management System (EMS) or Building Automation System (BAS) as one of the shutoff control functions.

References: Sections 130.1(c)

ICONOGRAPHY GUIDE: Constraints



Lighting Power Density

In nonresidential compliance, once mandatory requirements are satisfied, lighting power density (LPD) allowances must be satisfied. The evaluation can be done through one of three ways; Prescriptive, Performance or Tailored. Prescriptive is the simplest and can be done at the building or space level. Be aware that the luminaires power can be reduced by a power adjustment factor (PAF) when coupled with certain controls that are not part of the Mandatory Requirements. The Tailored Method uses target illuminance values and calculated based upon the cavity ratio to determine LPD for general lighting and allows for additional allowances for ornamental, wall display, etc. The Performance Method combines measures based upon Time Dependent Valuation (TDV).

References: Tables 140.6-A, 140.6-B, 140.6-C, 140.6-G; Sections 130.1(d), 130.1(e), 140.3(c), 140.6(a), 140.6(b), 140.6(c),



Daylight Opening

Title 24 uses the total opening area in square feet within a building and parking structure determine the need for daylighting controls. The opening in a parking structure can be glazing or an opening and the starting point is 36 square feet. For the inside of a building, the glazing starting point is 24 square feet.

References: Section 130.1(d)



Square Footage Range

Title 24 utilizes the area of a space to determine when to apply the mandatory requirements. Some examples include office size, controlled space, cumulative permitted work area for Demand Response, etc.



BUG / Zonal Lumen Requirements

Title 24 outdoor requirements for luminaires rated greater than 150 watts are required to meet the zonal lumen requirements.

References: Tables 130.2-A, 130.2-B; Sections 130.2(b)



Maximum Wattage Controlled Together

Title 24 requirement establishes the maximum wattage that can be controlled together to apply the mandatory requirements.

References: Sections 130.1(c), 130.2(c)



Height of Luminaire for Outdoor

In nonresidential outdoor compliance the luminaire height will determine what Mandatory Measures have to be implemented to meet Title 24 requirements. When luminaires mounted 24 feet or below, automatic lighting control is required to minimize power consumption when unoccupied.

References: Sections 130.2(c)



24/7 Operation

Under Title 24, there are many conditions/constraints imposed where 24 hours a day and 365 days a year provide exemptions to the mandatory use of controls such as emergency egress and tunnel lighting.

Reference: Sections 130.1(c), 130.2(c), 130.3(a)

TITLE 24: General Education and Information

When is Title 24 Compliance Required?

CONSTRUCTION TYPE	REQUIRED	
New Construction	YES	Meeting Title 24 is required for all residential and nonresidential new construction projects.
Additions	YES	Meeting Title 24 is required for all residential and nonresidential additions.
Alterations (classified as "Retrofit")	Conditional	Based upon the resulting lighting power density and percentage of luminaires altered. Refer to Table 141.0-E
Modification-in-Place (classified as "Retrofit")	Conditional	Based upon the resulting lighting power density and number of luminaires modified. Refer to Table 141.0-F
Repairs	No	Generally, no compliance required.

Note: As a general rule, when a permit is needed Title 24 Compliance is required.

Overview for Nonresidential Compliance



Step 1

ANALYZE THE FOLLOWING MANDATORY MEASURES FOR EACH SPACE

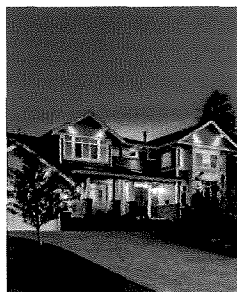
1. Space level (area control) required to operate the lighting.
2. Multi-level lighting requirements for appropriate dimming based on square footage and number of luminaires and/or lamps.
3. Controls providing shutoff reduce the lighting energy load based upon occupancy or schedule.
4. Daylighting controls capable of shedding load to eliminate energy waste when enough daylight is available.

Step 2

STAY WITHIN ALLOWABLE ENERGY BUDGET USING EITHER OF THESE OPTIONS:

1. **PRESCRIPTIVE APPROACH:**
Based on Lighting Power Density (LPD) limits. Use of controls independent of Mandatory Measures can reduce claimed lighting load by a Power Adjustment Factor (PAF) that is as high as 40%.
2. **PERFORMANCE APPROACH:**
Combined measures based upon Time Dependent Valuation (TDV).
3. **TAILORED METHOD:**
Uses target illuminance values and calculated based upon the cavity ratio to determine LPD for general lighting and allows for additional allowances for ornamental, wall display, etc.

Overview for Residential Compliance



Selection Process

EFFICACY REQUIREMENTS

Title 24 provides requirements for where High Efficacy and low efficacy luminaires can be installed on a room-by-room basis. High efficacy has different meanings for different luminaire types. In order to be classified as High Efficacy, LED luminaires are to meet JA8 requirements and certified to California Title 20 Appliance database. Compact fluorescent recessed luminaires require the ballast to be certified to California Title 20 Appliance database under "Ballast For Residential Recessed Luminaires". Fluorescent luminaires require the ballast to be certified to the California Title 20 Appliance database under "Ballast".



CONTROL REQUIREMENTS

Title 24 requires the use of controls to reduce power usage based upon room/area type and the luminaire used.



STRUCTURES CLASSIFIED AS RESIDENTIAL



Single Family Home



Multi-Family Home



High-Rise Home



Dormitory Living Quarters



Senior Living Quarters



Hotel/Motel/ Guest Rooms

TITLE 24: General Education and Information

Title 24 and Title 20: The Basics

T24 Can be used to comply with California Title 24 High Efficacy requirements

APPLIED AT THE BUILDING/SPACE LEVEL

- Similar: ASHRAE and LEED
- Product or combination of products commissioned properly meet the Title 24 requirements
- Example: Office space using Portfolio PD6 LED luminaire with occupancy and daylight sensors

T20 Certified to California Title 20 Appliance Database

APPLIED AT THE PRODUCT LEVEL

- Similar: DLC qualified and ENERGY STAR® certified products
- Certified to the California Energy Commission Title 20 Appliance Database
- Equipment tested and certified to meet Appliance Efficiency Regulations (and listed on the T20 database)
- Example: Wall Box Dimmer, Ceiling Daylight Sensor, Occupancy Sensor, Automatic Time Switch, Emergency Exit, etc

Egress Requirements for Meeting Title 24 (Nonresidential only)

SPACE TYPE	REQUIRED	
Exit	Yes	Exit signs must be certified to California Title 20 Appliance Database.
Building Level	No	No Title 24 compliances required.
Space Level	Conditional	Egress lighting more than 0.2 watts per square foot within an area enclosed by a ceiling height space must have a manual ON/OFF control switch but not accessible to unauthorized personnel.
Multi-Level Dimming	Yes	Code requires luminaires to be dimming capable even though the functionality is not enabled.
Shut-OFF	Conditional	Up to 0.05 watts per square foot may be continuously illuminated in enforcement agency designated egress area. Stairwells, corridors in hotel/motel and high-rise require a minimum of 50%.
Daylighting	Conditional	No Title 24 compliances required. Up to 0.05 watts per square foot may be continuously illuminated in designated egress areas.

Title 24 makes special accommodations for egress lighting and must be identified on the building design documents. Egress must be shut off after typically unoccupied times, except in offices (0.05 W/ft2 allowed 24/7).

Demand Response (Nonresidential building level mandatory requirement)

Demand Response required when 10,000 square feet or more are built or altered. Nonresidential interior code requirements call for each building, including parking garages, to be capable of responding to demand response signals when the building is greater than 10,000 square feet. The installation must be capable of shedding a minimum of 15% of the lighting loads with uniform dimming which utilizes the luminaire requirements of Table 130.1-A for multi-level dimming. This is a required building level evaluation when determining the requirements for Title 24 compliances.

Reference: See 130.1(e) page 144



Demand Response



Luminaire Dimming

Daylighting Details (Nonresidential only)

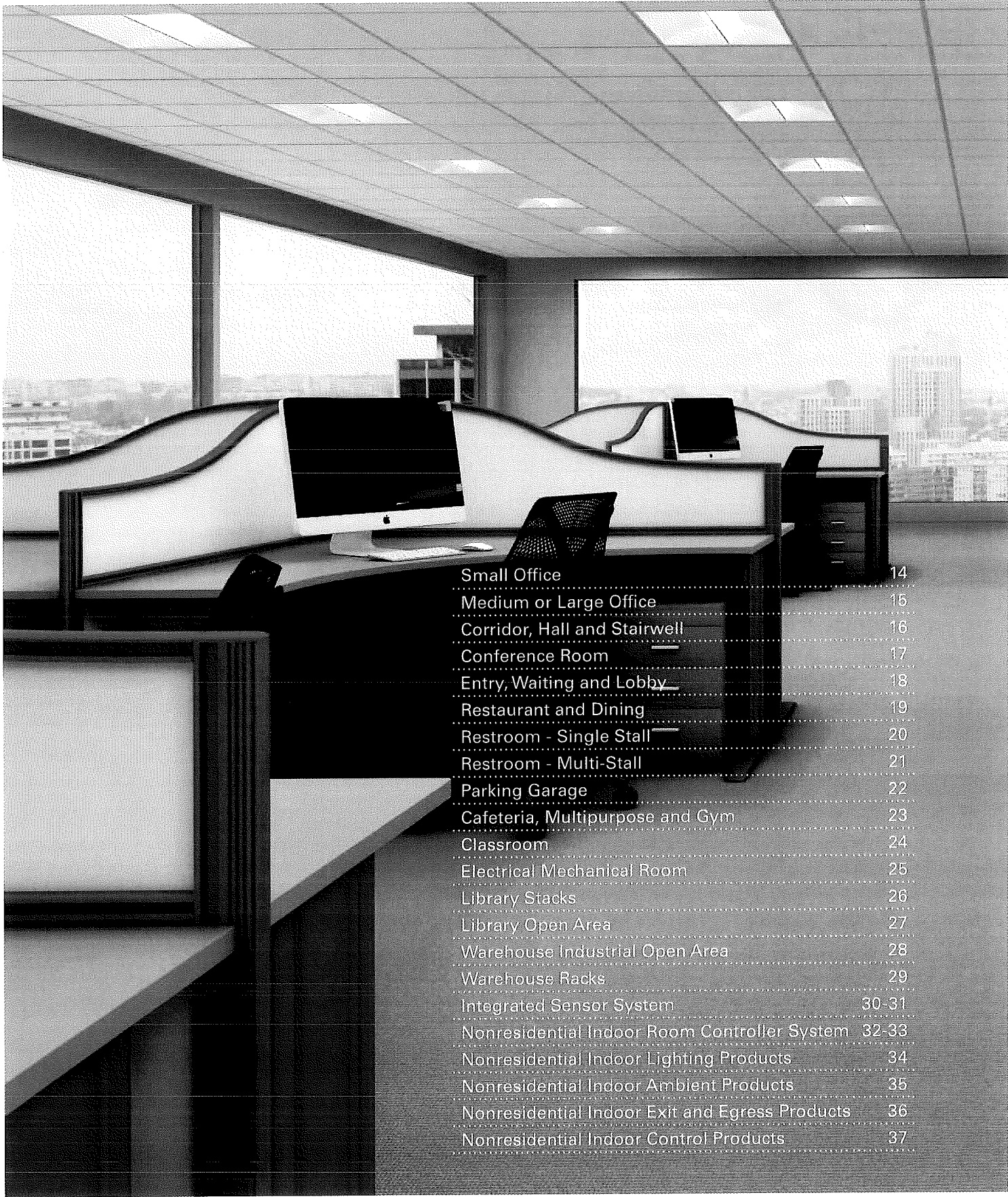
Daylighting in Title 24 Nonresidential Indoor compliance include skylit and sidelit daylighting types. Daylighting control is a mandatory requirement in spaces where daylighting is present. The location of the daylighting zones considers the obstructions and the types when determining how the controls are specified.

Zones where luminaires are in or at least 50% within the daylighting zones must be controlled. Each luminaire within the zone require uniform dimming. The daylighting zone must be controlled such that the darkest area of the zone target light levels do not exceed 150% of designed light levels and the lighting would be reduced to a minimum.

Reference: Nonresidential Compliance Manual section 5.4.4, 130.1(d), 140.6(d)

Nonresidential Interior	Parking Garage	Required Controls
<ul style="list-style-type: none"> • Up to 0.05 watts per square foot may be continuously illuminated in enforcement agency designated egress area. This is the only exception. • Sidelit or Skylight Openings >24 sqft. • Lighting power is 120W or greater in the daylight zone • Reduce at least 65% power when daylight provides more than 150% design illuminance 	<ul style="list-style-type: none"> • Sidelit Openings >36 sqft. • Lighting power is 60W or greater in the daylight zone • Turn off power when daylight provides more than 150% design illuminance 	 Luminaire Dimming Control Daylighting Control

Nonresidential Indoor Applications

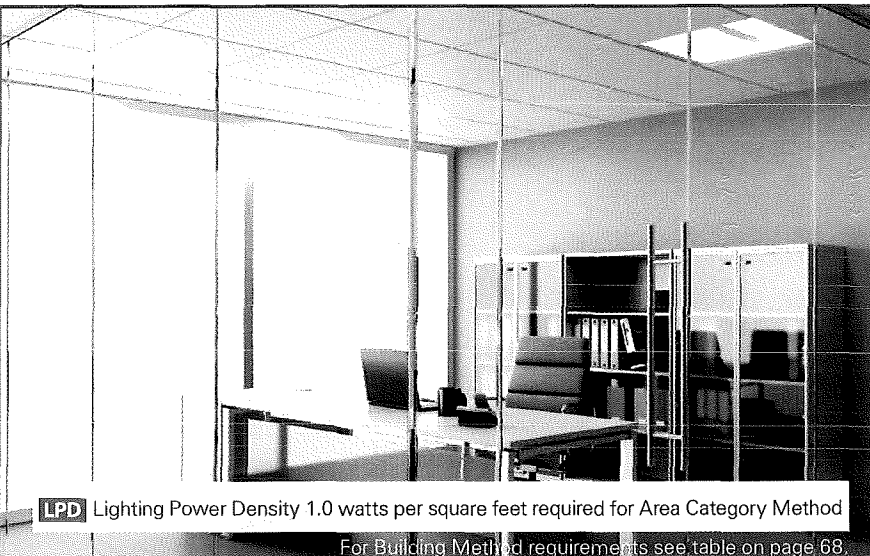


Small Office	14
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SPACE ASSUMPTIONS

- **Space** – 250 square feet or less
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring daylighting for both primary and secondary sidelit zones
- **Building** – When lighting project permitted area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144

**SPACE LEVEL (AREA CONTROL)**

- Must be accessible to occupants to operate the lighting



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Exceptions when multi-level control not required:

- <100 square feet
- 1 luminaire with a maximum of 2 lamps
- LPD up to 0.2W/sf



Luminaire
Dimming



Manual
Dimmer



Lumen
Maintenance
Control



Tuning
Control



Daylighting
Control



Demand
Response

(OPTIONAL)

Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- 120V receptacles only having one controlled receptacle within 6 feet of uncontrolled receptacle



Occupancy
Sensor



Manual On/
Auto Off



Receptacle
Control

(CHOOSE ONE)

Reference:
See 130.1(c)
page 141,
130.5(d) pages
151-152

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Luminaire
Dimming

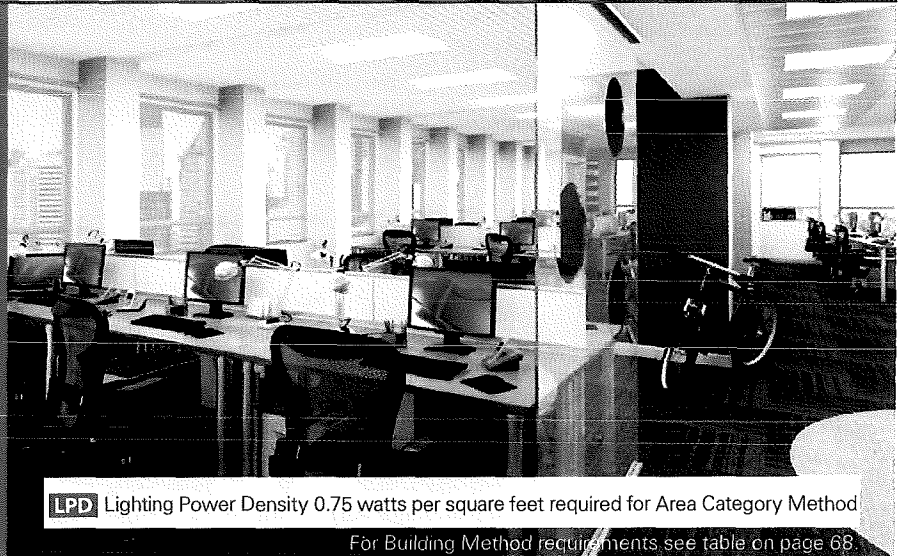


Daylighting
Control

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – Greater than 250 square feet
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring automatic daylighting controls for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density 0.75 watts per square feet required for Area Category Method
For Building Method requirements see table on page 68.

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Capable of reducing power by at least one of four control functions
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.



Luminaire
Dimming



Manual
Dimmer



Lumen
Maintenance
Control



Tuning
Control



Daylighting
Control



Demand
Response

(OPTIONAL)

Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- 120V receptacles only having one controlled receptacle within 6 ft of uncontrolled receptacle
- Separate shut-off control for each 5,000 sq ft
- Automatic Time Switch control must have and override to remain on no more than 2 hours

Exceptions to shutoff control include:

- Lighting serving a continuous use area
- Emergency egress up to 0.05 watts per sq ft



Occupancy
Sensor



Manual On/
Auto Off



Remote Signal
Control



Automatic
Time Switch



Receptacle
Control

(CHOOSE ONE OR MORE)

Reference:
See 130.1(c)
page 141,
130.5(d) pages
151-152

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Luminaire
Dimming

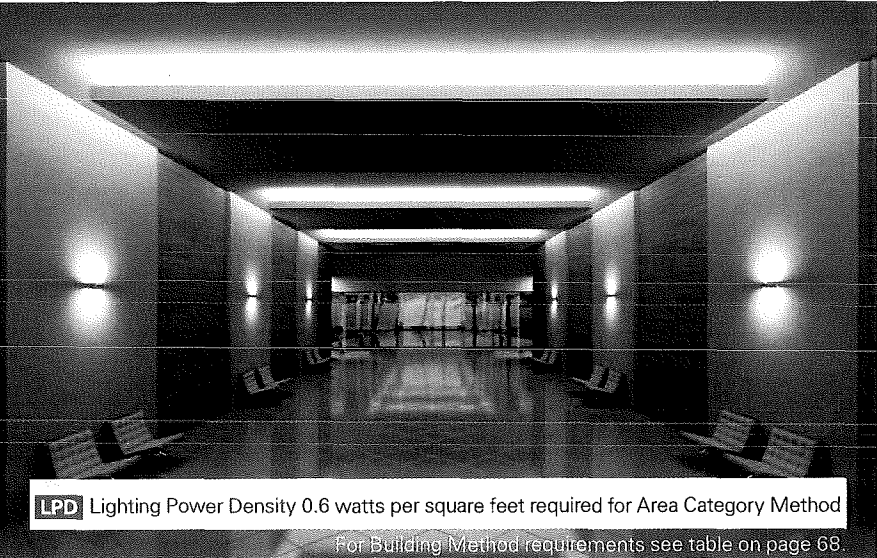


Daylighting
Control

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – Accessible areas
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring daylighting for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density 0.6 watts per square feet required for Area Category Method
 For Building Method requirements see table on page 68.

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

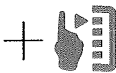
- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Exceptions when multi-level control not required:

- <100 square feet
- 1 luminaire with a maximum of 2 lamps



Luminaire
Dimming



Manual
Dimmer



Lumen
Maintenance
Control



Tuning
Control



Daylighting
Control



Demand
Response

(OPTIONAL)

Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires drop to at least 50% power when space is vacant, "high level" with occupant sensed in all accessible areas
- When space is not in a hotel/motel or high-rise residential, during non-business hours and the building is unoccupied, the lights are turned off



Occupancy
Sensor



Remote Signal
Control



Automatic
Time Switch

(OPTIONAL)

Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Luminaire
Dimming

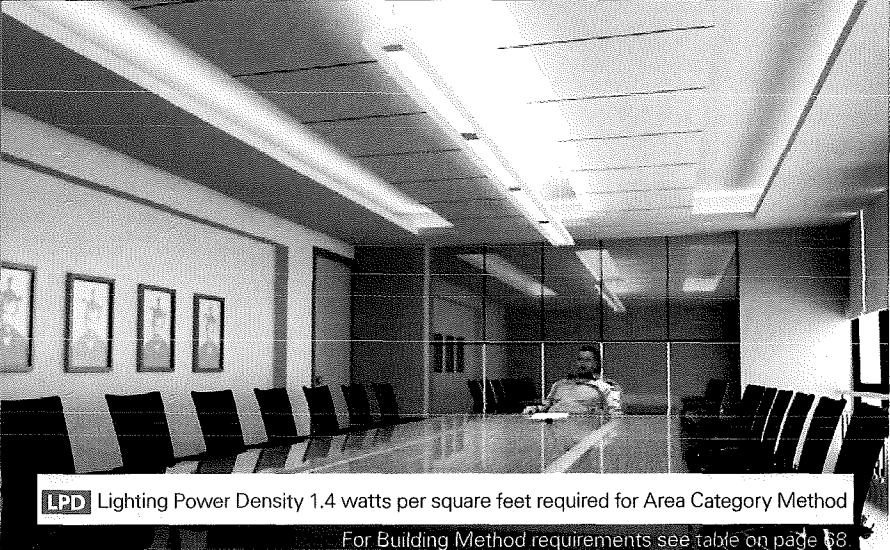


Daylighting
Control

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring daylighting for both primary and secondary sidelit zones
- **Others** – The general lighting is not intended to for continuous use, 24 hours and 365 day use. Egress lighting is not part of the general lighting use.
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density 1.4 watts per square feet required for Area Category Method
 For Building Method requirements see table on page 68.

SPACE LEVEL (AREA CONTROL)

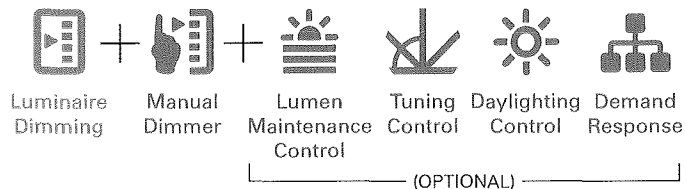
- Must be accessible to occupants to operate the lighting



Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

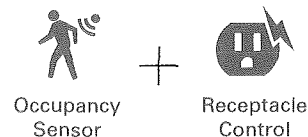
- Luminaire must provide uniform dimming
- Capable of reducing power by at least one of four control functions
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.



Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

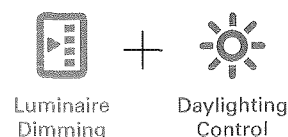
- Luminaires turned off when vacant
- 120V receptacles only having one controlled receptacle within 6 feet of uncontrolled receptacle



Reference:
See 130.1(c)
page 141,
130.5(d) pages
151-152

AUTOMATIC DAYLIGHTING CONTROL


- Eliminate energy waste when natural light present
- Exceptions when daylighting control not required:
- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring daylighting for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density as low as 1.5 watts per sq ft required for Area Category Method

For Building Method requirements, see table on page 68.

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Exceptions when multi-level control not required:

- <100 square feet
- 1 luminaire with a maximum of 2 lamps



Luminaire
Dimming



Manual
Dimmer



Lumen
Maintenance
Control



Tuning
Control



Daylighting
Control



Demand
Response

(OPTIONAL)

Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- 120V receptacles only having one controlled receptacle within 6 ft of uncontrolled receptacle
- Separate shut-off control for each 5,000 sq ft
- Automatic Time Switch control must have and override to remain on no more than 2 hours

Exceptions to shutoff control include:

- Lighting serving a continuous use area
- Emergency egress up to 0.05 watts per sq ft



Occupancy
Sensor



Manual On/
Auto Off



Remote Signal
Control



Automatic
Time Switch



Receptacle
Control

(CHOOSE ONE OR MORE)

Reference:
See 130.1(c)
page 141,
130.5(d) pages
151-152

AUTOMATIC DAYLIGHTING CONTROL

- General illumination required to be controlled
- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Luminaire
Dimming

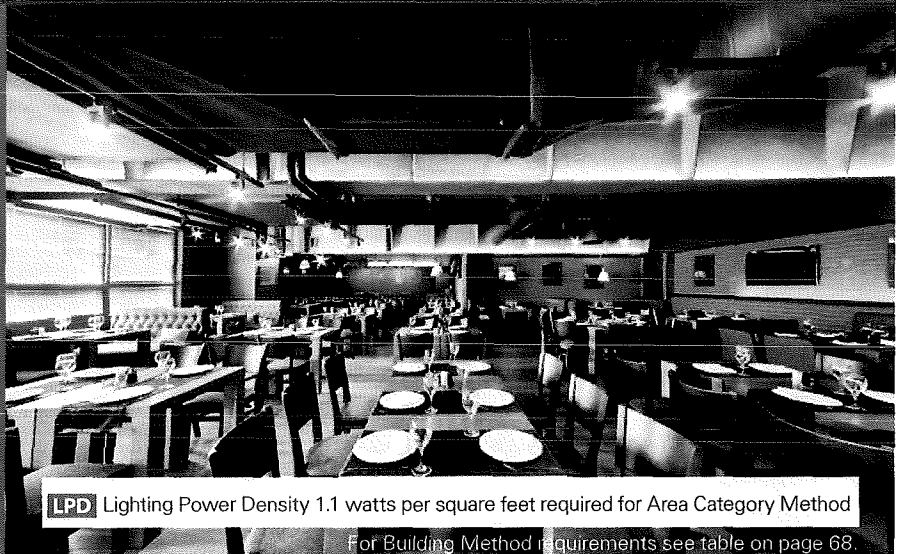


Daylighting
Control

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger. Excludes food prep and kitchen areas.
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring daylighting for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Capable of reducing power by at least one of four control functions
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.



Luminaire
Dimming



Manual
Dimmer



Lumen
Maintenance
Control



Tuning
Control



Daylighting
Control



Demand
Response

(OPTIONAL)

Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- Separate shut-off control for each 5,000 sq ft
- Automatic Time Switch control must have an override to remain on no more than 2 hours

Exceptions to shutoff control include:

- Lighting serving a continuous use area
- Emergency egress up to 0.05 watts per sq ft



Occupancy
Sensor



Manual On/
Auto Off



Remote Signal
Control



Automatic
Time Switch

(CHOOSE ONE OR MORE)

Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- General illumination required to be controlled
- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Luminaire
Dimming

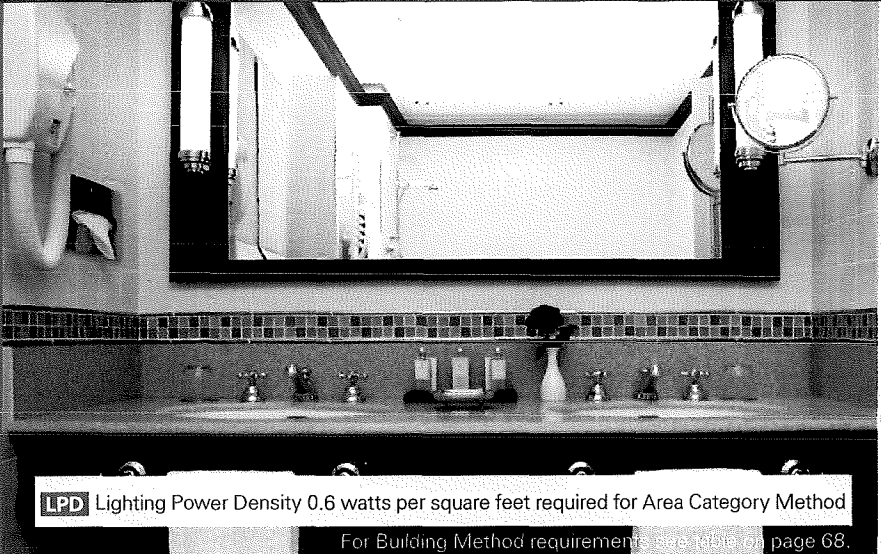


Daylighting
Control

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – Greater than 100 square feet and less than 5000 square feet
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Does not contain glazing larger than 24 square feet total daylighting for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(f) page 144



LPD

Lighting Power Density 0.6 watts per square feet required for Area Category Method

For Building Method requirements see table on page 68.

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting



Manually Switched
ON/OFF

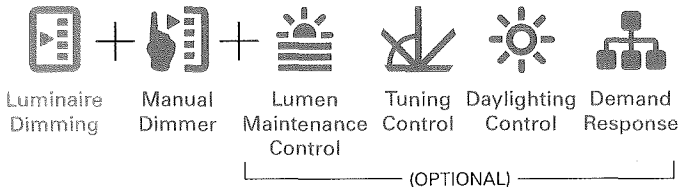
Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Exceptions when multi-level control not required:

- <100 square feet
- 1 luminaire with a maximum of 2 lamps



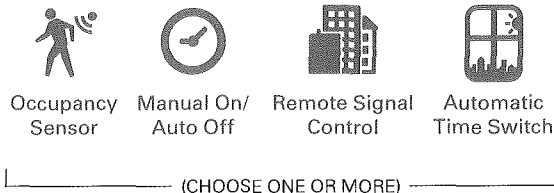
Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- Automatic Time Switch control must have and override to remain on no more than 2 hours

Exception when shutoff control not required:

- Countdown timer can be used only in bathrooms and closets less than 70 square feet but no more than 10 minutes.



Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

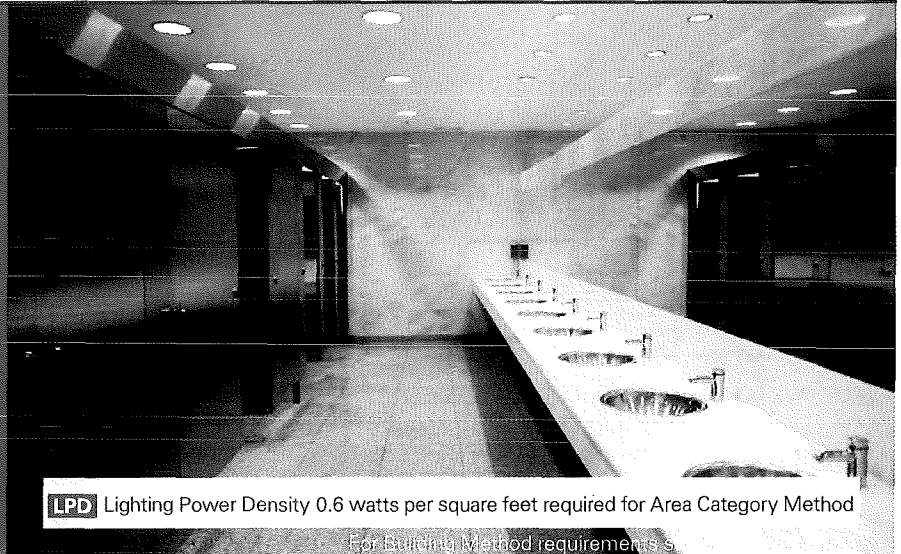
- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W

AUTOMATIC DAYLIGHTING CONTROL NOT REQUIRED
BECAUSE EXCEPTIONS MOST LIKELY APPLY

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – Greater than 100 square feet and less than 5000 square feet
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Does not contain glazing larger than 24 square feet total daylighting for both primary and secondary sidelit zones
- **Others** – The general lighting is not intended to for continuous use, 24 hours and 365 day use. Egress lighting is not part of the general lighting use.
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



SPACE LEVEL (AREA CONTROL)

- May use a manual switch not accessible to unauthorized personnel



Manually Switched
ON/OFF

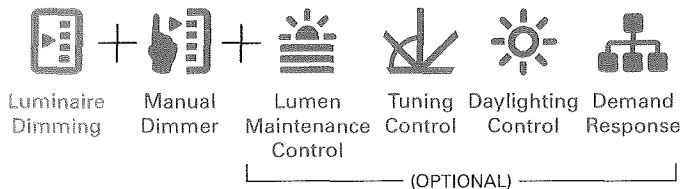
Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Exceptions when multi-level control not required:

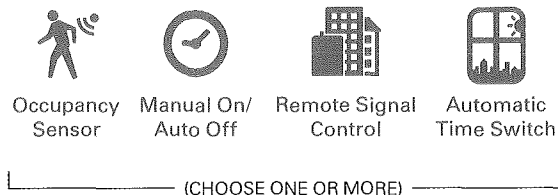
- <100 square feet
- 1 luminaire with a maximum of 2 lamps



Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- Automatic Time Switch control must have and override to remain on no more than 2 hours



Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W

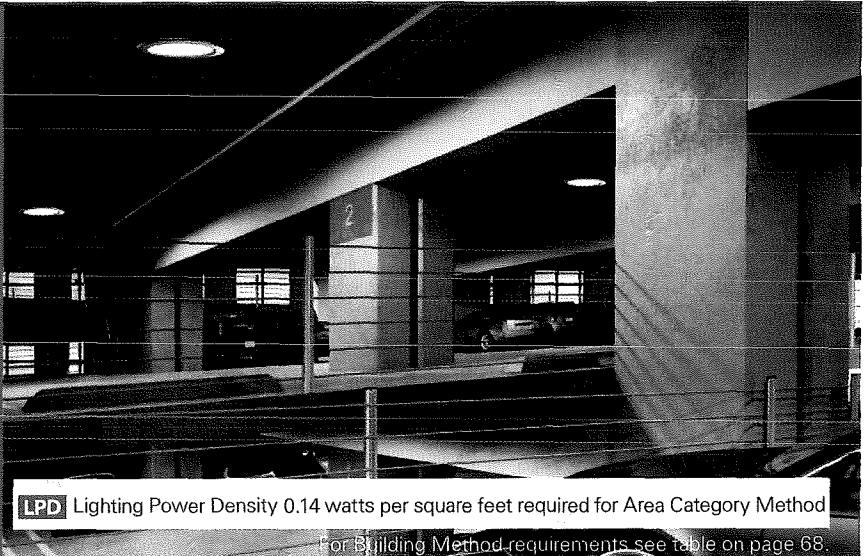
AUTOMATIC DAYLIGHTING CONTROL NOT REQUIRED
BECAUSE EXCEPTIONS MOST LIKELY APPLY

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger. Includes the interior areas of parking garages* and residential carports with 8 or more vehicles; can apply to low-rise multifamily residential buildings with less than 8 vehicles.
- **Electrical Load** – No more than 0.14 watts per square feet planned for the general area
- **Daylighting** – Does not include Daylight transition zones or Daylight Adaptive zones
- **Building** – If considered a habitable space and when cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144

* Note this excludes the top deck of parking garages which are considered hardscapes. Hardscapes must comply with outdoor lighting requirements.



SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting
- Check with local building department for common exemptions.

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Not required except when daylighting control is required

MULTI-LEVEL LIGHTING IS NOT REQUIRED
FOR THE LIGHTING POWER DENSITY SPECIFIED
IN PARKING GARAGES

Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- At least one control step between 20% and 50% power when vacant, "high level" with occupant sensed for control zone
- No more than 500W controlled together in a single zone



Occupancy
Sensor

Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing/openings <36 square feet; Daylit zone is less than 60W



Luminaire
Dimming



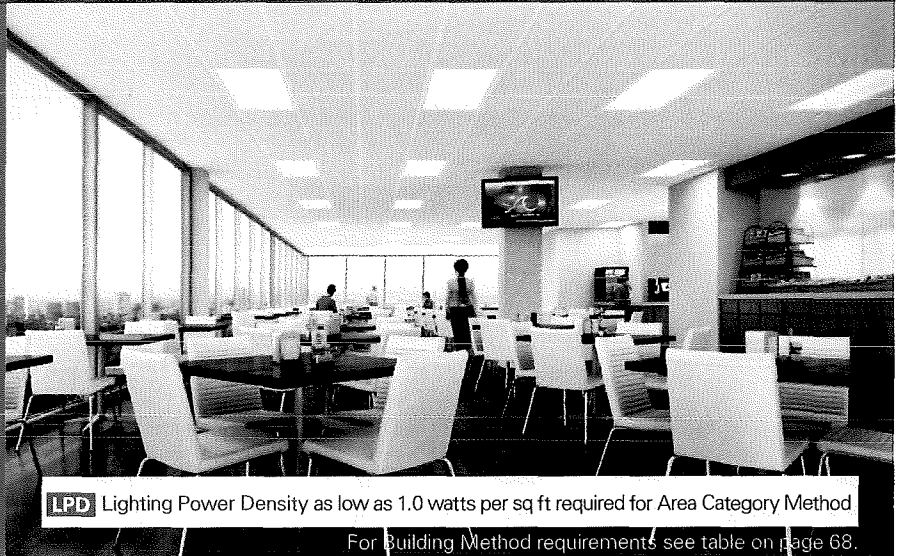
Daylighting
Control

Luminaire Control can be ON/OFF

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring daylighting for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density as low as 1.0 watts per sq ft required for Area Category Method
For Building Method requirements see table on page 68.

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel

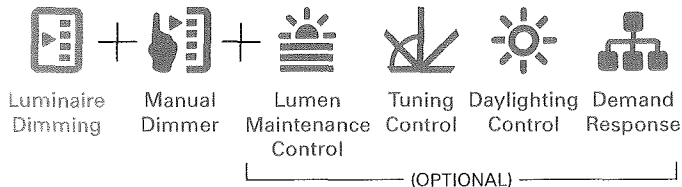


Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

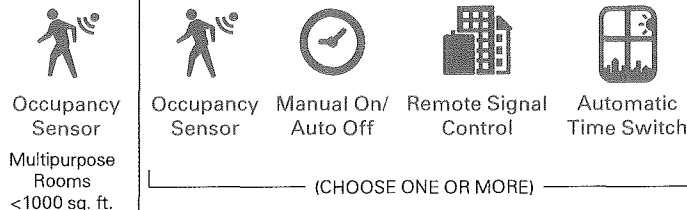
- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.



Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- Separate shut-off control for each 5,000 sq ft
- Automatic Time Switch control must have and override to remain on no more than 2 hours



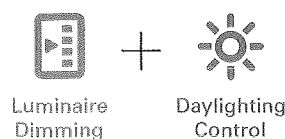
Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

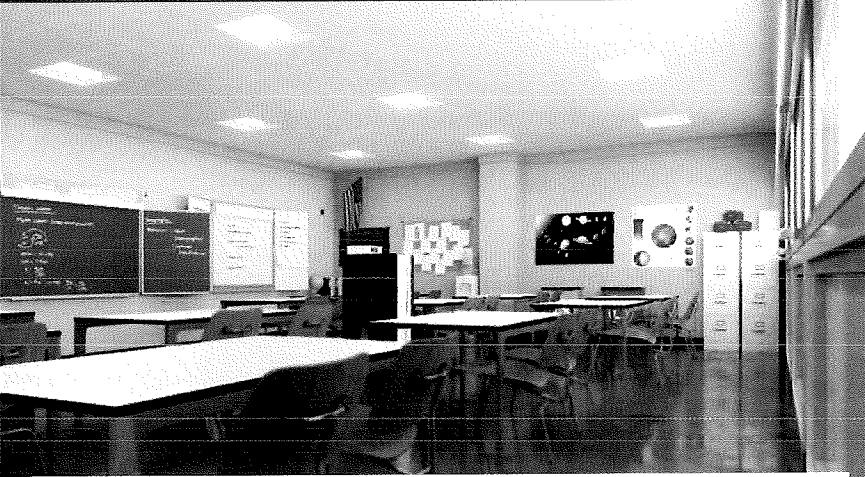
- Areas with no skylights or glazing < 24 square feet; Daylit zone is less than 120W



Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – Classroom of any size
- **Electrical Load** – Greater than 0.7 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring automatic daylight controls for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density 1.2 watts per square feet required for Area Category Method
For Building Method requirements see table on page 68

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present.

Exception when multi-level control not required:
• Minimum of one control step between 30% and 70% is required



Luminaire
Dimming



Manual
Dimmer

Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant



Occupancy
Sensor



Manual On/
Auto Off

(CHOOSE ONE)

Reference:
See 130.1(c)
page 141,
130.5(d) pages
151-152

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:
• Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Luminaire
Dimming




Daylighting
Control

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – Non-habital space
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density 0.7 watts per square feet required for Area Category Method
For Bundling Method requirements see table on page 68.

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting



Manually Switched
ON/OFF

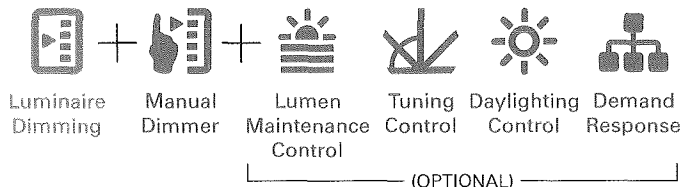
Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Exceptions when multi-level control not required:

- <100 square feet
- 1 luminaire with a maximum of 2 lamps

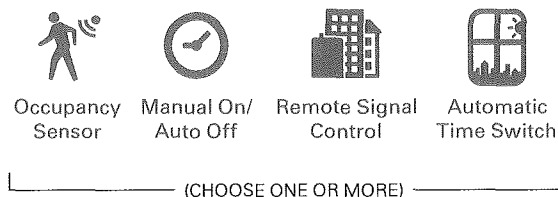


Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant

Electrical rooms - Must comply with Article 110.26(D) of the California Electrical Code. Generally, Auto Shutoff should not be used.



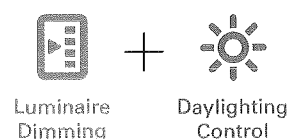
Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:


- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring automatic daylight controls for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density 1.5 watts per square feet required for Area Category Method

For Building Method requirements, see applicable on page 158

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel

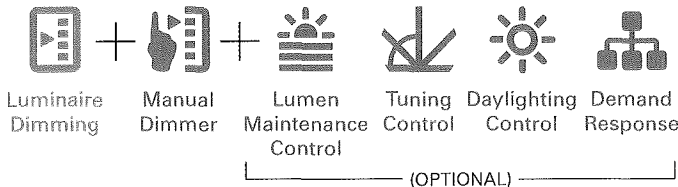


Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Capable of reducing power by at least one of five control functions
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.



Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires drop to at least 50% power when space is vacant, "high level" with occupant sensed in
- During non-business hours and the building is unoccupied, the lights are turned off.
- Library Stack Aisle 10 feet or longer accessible from one end and Aisles 20 feet and longer accessible from both ends. Each aisle independently controlled.



Occupancy
Sensor

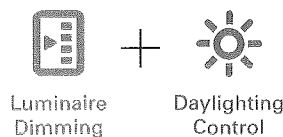
Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

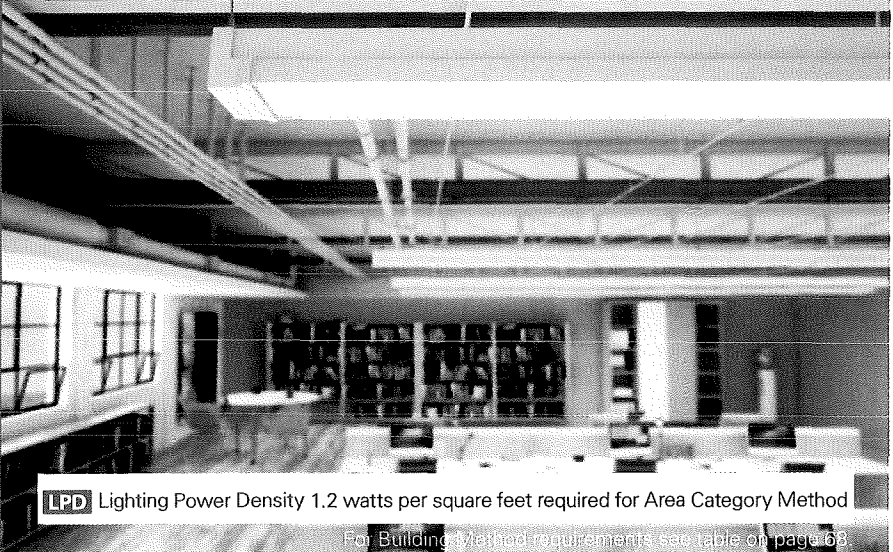
- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring automatic daylight controls for both primary and secondary sidelit zones
- **Others** – The general lighting is not intended to for continuous use, 24 hours and 365 day use. Egress lighting is not part of the general lighting use.
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density 1.2 watts per square feet required for Area Category Method

For Building Method requirements see table on page 68

SPACE LEVEL (AREA CONTROL)

- Must be accessible to occupants to operate the lighting

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Exceptions when multi-level control not required:

- <100 square feet
- 1 luminaire with a maximum of 2 lamps



Luminaire
Dimming



Manual
Dimmer



Lumen
Maintenance
Control



Tuning
Control



Daylighting
Control



Demand
Response

(OPTIONAL)

Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- Each 5,000 square feet to have shutoff controls
- Automatic Time Switch control must have and override to remain on no more than 2 hours



Occupancy
Sensor



Manual On/
Auto Off



Remote Signal
Control



Automatic
Time Switch

(CHOOSE ONE OR MORE)

Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Luminaire
Dimming

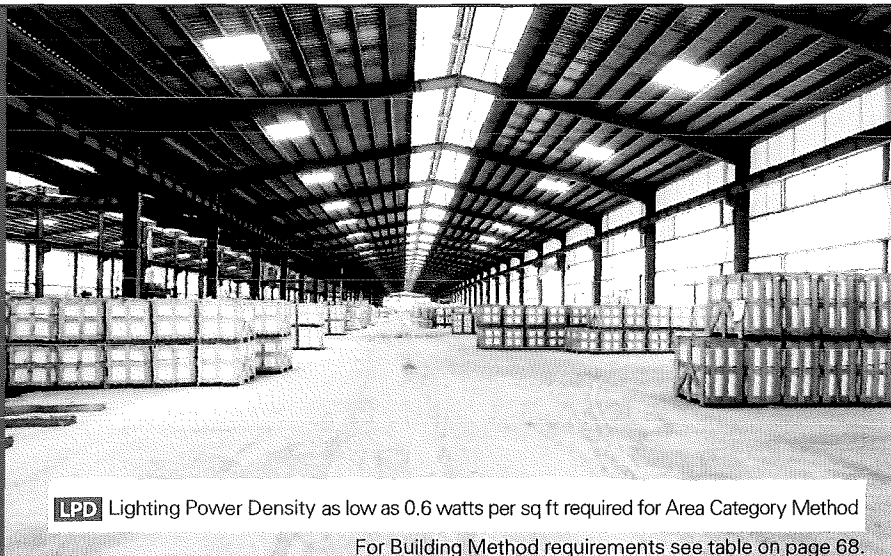


Daylighting
Control

Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring automatic daylight controls for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144

**SPACE LEVEL (AREA CONTROL)**

- Located so that a person using the control can see the lights or area being lit is annunciated
- Exception when space level control not required:
- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel

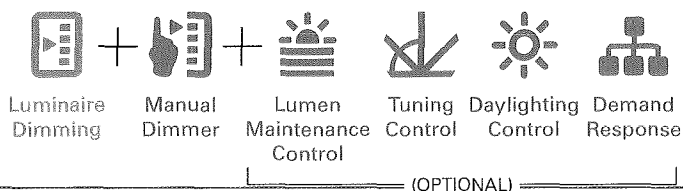


SPACE LEVEL CONTROL NOT
REQUIRED FOR WAREHOUSE
APPLICATIONS

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

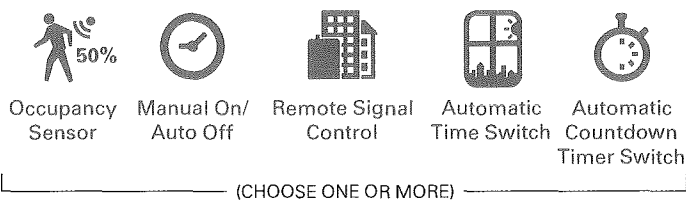
- Luminaire must provide uniform dimming
- Capable of reducing power by at least one of five control functions
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.



Reference:
See 130.1(a & b)
page 140

SHUTOFF CONTROL

- Luminaires in warehouses are to drop to at least 50% power when space is vacant, "high level" with occupant sensed in
- During non-business hours and the building is unoccupied, the lights are turned off
- Separate shut-off control for each 5,000 sq ft
- Automatic Time Switch control must have and override to remain on no more than 2 hours.
- Captive key override can be used to the override control for automatic time switch which can exceed the 2 hour override limit



Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present
- Exceptions when daylighting control not required:
- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Reference:
See 130.1(d)
page 143

SPACE ASSUMPTIONS

- **Space** – 100 square feet or larger
- **Electrical Load** – Greater than 0.5 watts per square feet planned
- **Daylighting** – Contains skylights or glazing larger than 24 square feet total requiring automatic daylight controls for both primary and secondary sidelit zones
- **Building** – When cumulative permitted work area is larger than 10,000 square feet Demand-Response is required (capable of lowering lighting power by 15%). Reference: See 130.1(e) page 144



LPD Lighting Power Density 0.6 watts per square feet required for Area Category Method
For Building Method requirements see table on page 68.

SPACE LEVEL (AREA CONTROL)

- Located so that a person using the control can see the lights or area being lit is annunciated

Exception when space level control not required:

- Up to 0.2 W/sf of egress area may be continuously illuminated and the control is not accessible to unauthorized personnel



Manually Switched
ON/OFF

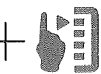
Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Capable of reducing power by at least one of five control functions
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.



Luminaire
Dimming



Manual
Dimmer



Lumen
Maintenance
Control



Tuning
Control



Daylighting
Control



Demand
Response

(OPTIONAL)

Reference:
See 130.1(a &b)
page 140

SHUTOFF CONTROL

- At least 50% power when aisles are vacant, "high level" with occupant sensed at all accessible areas
- Warehouse racking are also controlled independently



Occupancy
Sensor

Reference:
See 130.1(c)
page 141

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W



Luminaire
Dimming



Daylighting
Control

Reference:
See 130.1(d)
page 143

NONRESIDENTIAL INDOOR: Integrated Sensor System

INTEGRATED SENSOR SYSTEM

The luminaire integrated sensor system from Eaton reduces the design time and complexity of Title 24 compliance for both lighting and controls.



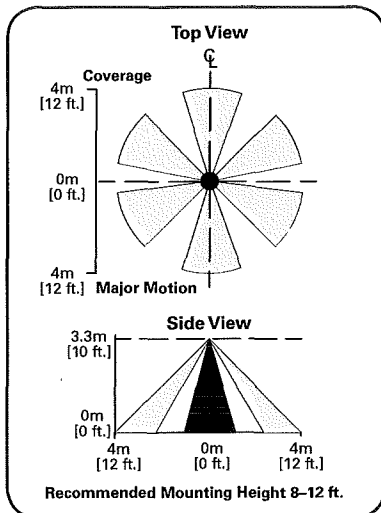
The sensor system is designed to guarantee occupancy and daylight harvesting coverage from within the footprint of an ambient luminaire, so the lighting design is the controls design.

The integrated sensor system is the out of the box solution to meeting the latest California Title 24 lighting non-residential indoor requirements found in Section 130.1.

The sensor system is factory-wired to the each luminaire, switching on and off based on occupancy, and dimming the light when enough daylight is available.

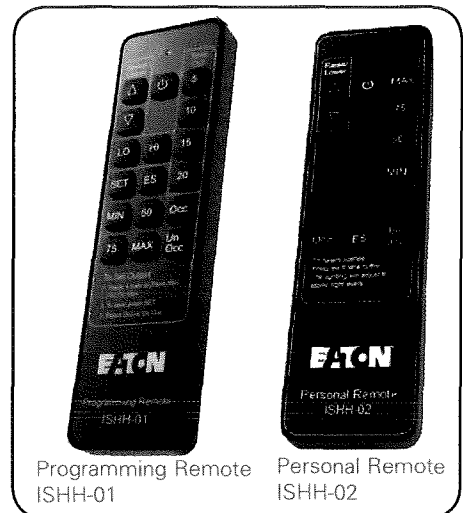
Eaton luminaires with integrated sensors are the most cost-effective solution for enclosed spaces with six or fewer fixtures.

- Private Offices
- Patient/Exam Rooms
- Fitness Centers
- Small Conference Rooms
- Small Classrooms
- New Construction or Renovation
- Storage Areas



Integrated Design

The sensor system adds to the contemporary aesthetic of Eaton LED luminaires. The system is factory wired and ready to meet Title 24 code out of the box.



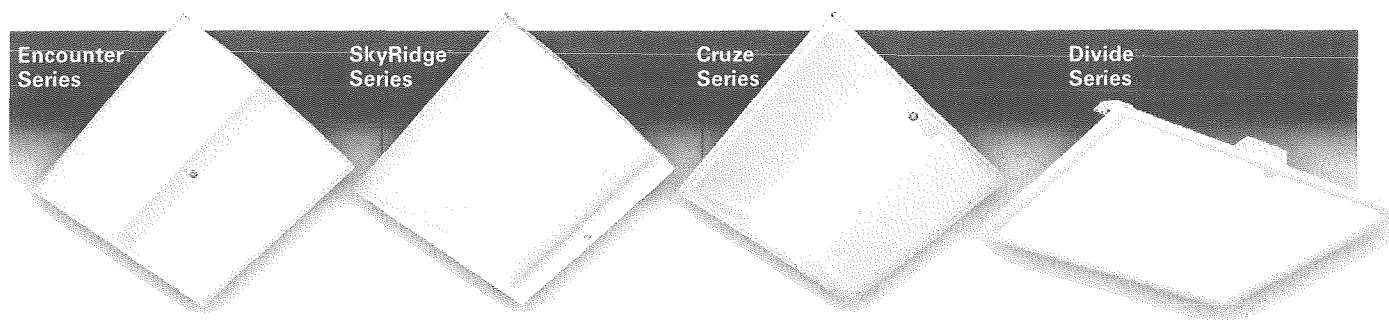
Sensor Remote Control

The optional remote can be used to change settings and to provide local control for one or more fixtures in the same area, allowing users to adjust light levels, even temporarily override automatic controls. Choose one per project for programming, and at least one Personal Remote per zone.

Worry-free Controls Planning

Ensure seamless coverage and performance with a sensor system built into every luminaire. The multi-technology sensor's occupancy and light sensing coverage overlaps the area each fixture illuminates.

NONRESIDENTIAL INDOOR: Integrated Sensor System



These luminaires equipped with the integrated sensor system exceed California Title 24 requirements:

SPACE LEVEL (AREA CONTROL)

The sensor system keeps its settings even when power is cycled allowing the system to be combined with area controls, including manual switches. Luminaires with the sensor system can be switched on/off using a standard switch, while gaining the benefit of the occupancy sensing and daylight dimming controls commissioned.

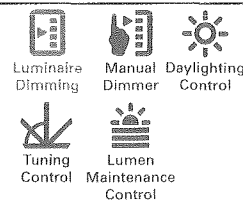


Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

Luminaires equipped with the integrated sensor system satisfy the requirement of continuous dimming 10-100% and uniform level of illuminance found in Table 130.1-A.

The integrated sensor system meets many of the optional requirements found under multi-level lighting control, including manual dimming using the optional personal control remote, tuning, and automatic daylighting.



Reference:
See 130.1(b)
page 140-141,
and table
130.1-A page
145

SHUTOFF CONTROL

The integrated sensor offers shut-off control with the occupancy sensor turning the lighting off when the space is unoccupied. The sensor complies with California's Title 20 Appliance regulations, assuring that the commissioning inspection passes with a 20-minute time-out.

The flexibility of the integrated sensor system allows for programming with the optional programming remote to the partial ON/OFF occupant sensing controls found in spaces such as corridors and hotel common areas, reducing the power by at least 50%.



Reference:
See 130.1(c)
page 141-142

AUTOMATIC DAYLIGHTING CONTROL

All sky-lit zones, primary and secondary day-lit zone, requirements can be easily commissioned to service these defined zones more discretely by taking this requirement to the luminaire level without having to differentiate between these zones.

The integrated photo sensors are programmed with a separate programming remote by authorized personnel, enabling the capabilities of the multi-level lighting from the LED luminaires the sensor is integrated into.



Reference:
See 130.1(d)
page 143-144

DEMAND RESPONSIVE CONTROL

The integrated sensor allows for the 0-10Vdc input of the luminaire to be accessed by the demand responsive node to reduce the lighting by at least 15% when a DR event is called. Contact factory for wiring requirements.



Reference:
See 130.1(e)
page 144

LIGHTING POWER DENSITY ADJUSTMENT FACTOR (PAF)

Lighting Power Density Adjustment Factors can be easily utilized to secure lower LPD calculations for the spaces.

The integrated sensor capabilities exceed code requirements and offer more PAF options which results in more ways to control light using less power.



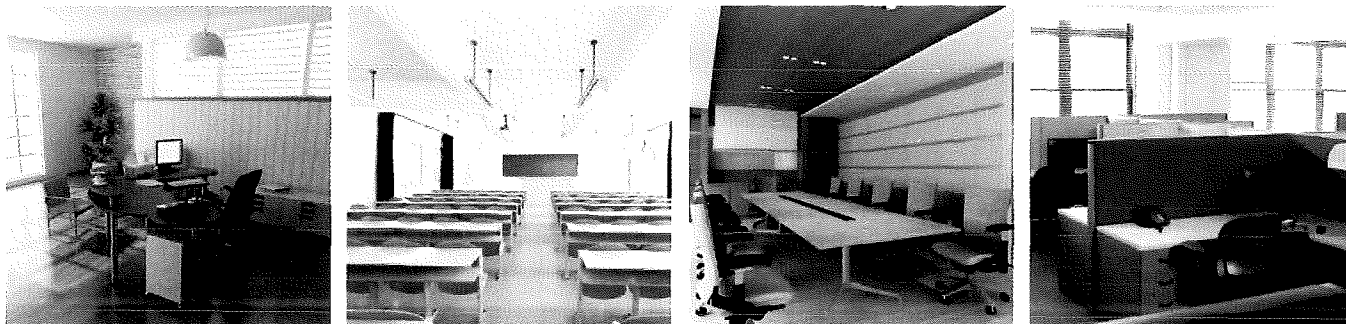
Reference:
See table
140.6-A page
189

NONRESIDENTIAL INDOOR: Room Controller System

ROOM CONTROLLER SYSTEM

The Room Controller System provides energy compliant lighting, plug and emergency control capabilities with out-of-the-box functionality in virtually any space. The system can be ordered based on specific budget or performance requirements.

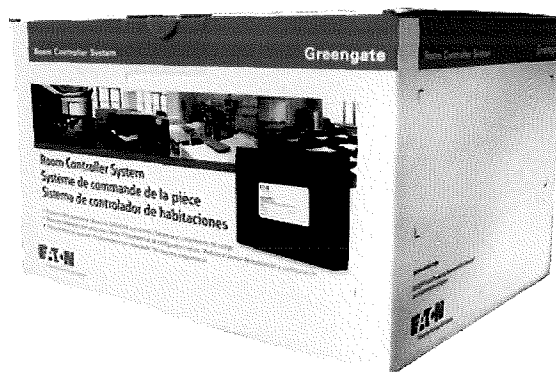
- Simplified compliance with a product designed to meet the latest energy codes
- Reduce cost of installation with single enclosure and simplified wiring
- Save time with out-of-the-box controls functionality, no programming needed



OUT OF THE BOX CONTROL SOLUTION

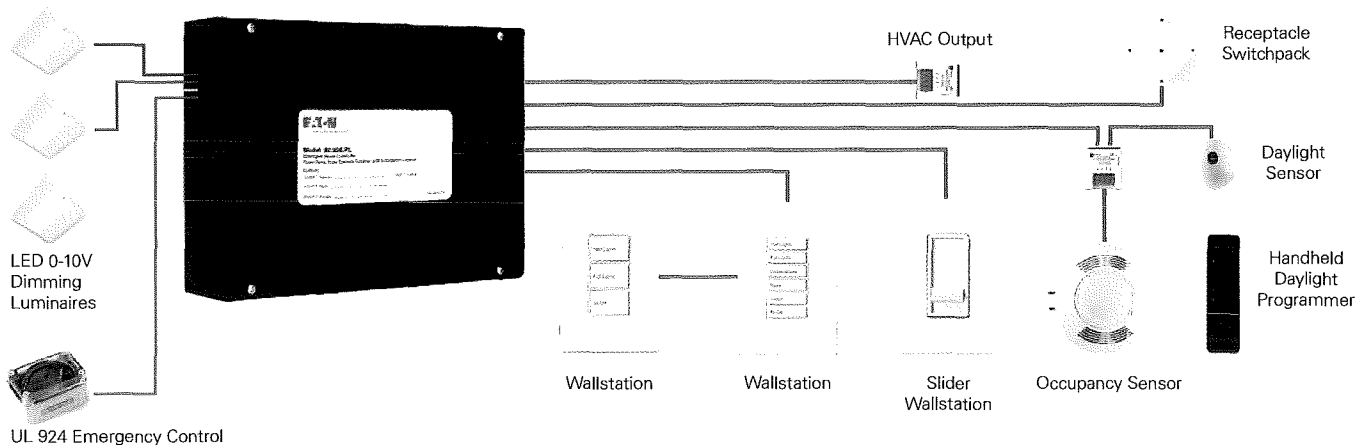
Room-by-room compliance is made easy with our Starter Kits and Quickkits. These kits are easy to order, designed and packaged for immediate in room installation and provide a complete all-in-one package solution.

Ideal Basic Electrical Distributor stocking products, everything the electrical contractor will need for installation above the ceiling. The Room Controller system is customized for each space and can be specified and ordered based on project needs. The Room Controller system is available in both a stand-alone and networked architecture.



HOW THE ROOM CONTROLLER SYSTEM WORKS

The system provides everything necessary for meeting mandatory Title 24 requirements including a wide variety of wallstations and sensors to solve all daylighting, dimming, vacancy and occupancy requirements. All appropriate control devices are listed on the Title 20 database.



NONRESIDENTIAL INDOOR: Room Controller System

ROOM CONTROLLER SYSTEM FEATURES AND CONTROL STRATEGIES



Area Control

The intuitive user interface provides for manual override and has pre-engraved buttons describing their respective functionality.



Occupancy Sensor

Any Greengate low voltage occupancy sensors can be used with the Room Controller, so select one to meet your applications needs.



Daylight Sensor

Dimmable daylighting requirements have increased with the latest version of Title 24. The daylight sensor allows up to three dimming zones to be controlled from a single sensor.



Receptacle Control

Saving additional energy by shutting off plug loads is now part of Title 24, and is easily achieved with the Receptacle Switchpack and the Room Controller.



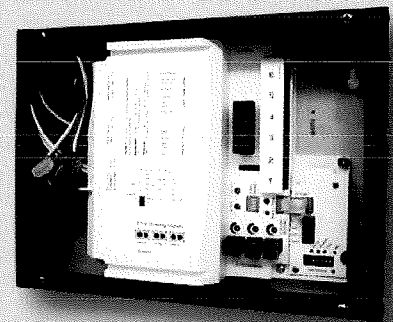
Demand Response

Title 24 requires that buildings larger than 10,000 square feet have demand responsive lighting controls capable of delivering a minimum of 15% reduction in lighting load in a uniform method.



Integration

Combining wallstations and sensors that are designed to work with the room controller and proven to meet code requirements is a simple and effective control solution.



ROOM CONTROLLER SYSTEM MEETS TITLE 24 REQUIREMENTS

SPACE LEVEL (AREA CONTROL)

- May use a manual switch not accessible to unauthorized personnel



Manually Switched
ON/OFF

Reference:
See 130.1(a)
page 140

MULTI-LEVEL LIGHTING

- Luminaire must provide uniform dimming
- Manual dimmer is required when a dimming luminaire is present. All other controls are optional.

Exceptions when multi-level control not required:

- <100 square feet
- 1 luminaire with a maximum of 2 lamps



Luminaire
Dimming



Manual
Dimmer



Lumen
Maintenance
Control



Tuning
Control



Daylighting
Control



Demand
Response

(OPTIONAL)

Reference:
See 130.1(a &b)
page 140

SHUTOFF CONTROL

- Luminaires turned off when vacant
- Each 5,000 square feet to have shutoff controls
- Automatic Time Switch control must have and override to remain on no more than 2 hours



Occupancy
Sensor



Manual On/
Auto Off



Receptacle
Control

(CHOOSE ONE)

Reference:
See 130.1(c)
page 141,
130.5(d) pages
151-152

AUTOMATIC DAYLIGHTING CONTROL

- Eliminate energy waste when natural light present

Exceptions when daylighting control not required:

- Areas with no skylights or glazing <24 square feet; Daylit zone is less than 120W in most areas



Luminaire
Dimming







Daylighting
Control

Reference:
See 130.1(d)
page 143

NONRESIDENTIAL INDOOR: Product Reference Guide

FEATURED NONRESIDENTIAL INDOOR LIGHTING PRODUCTS





These products are recommendations based on Title 24 requirements. There are many configuration combinations available in the products listed below. Due to ever-changing nature of evolving technologies other solutions may be available in addition to the ones below.

Fixture Type	Model	Product Line	Description				
				Luminaire Dimming	Optional Daylighting Control	Optional Occupancy Sensor	Emergency Backup (for Egress)
Recessed Lighting	EL406_	HALO	EL 4" LED	✓			
	ELG406_	HALO	ELG Round 4" Adjustable LED	✓			
	ELGS406_	HALO	ELG Square 4" Adjustable LED	✓			
	H750_	HALO	H7 LED housing	✓			✓
	H995_	HALO	H4 LED housing	✓			
	LD4A_	PORTFOLIO	L 4" Round Commercial LED	✓			✓
	LD6A_	PORTFOLIO	L 6" Round Commercial LED	✓			✓
	LD8A_	PORTFOLIO	L 8" Round Commercial LED	✓			✓
	LDSQ4A_	PORTFOLIO	L 4" Square Commercial LED	✓			✓
	LDSQ6A_	PORTFOLIO	L 6" Square Commercial LED	✓			✓
	ML5606_	HALO	ML 5" & 6" LED	✓			
	P3LED_	IRIS	P 3" Adjustable Commercial LED	✓			✓
	PD6_ED010_	HALO COMMERCIAL	PD 6" Commercial LED	✓			✓
	RA406_	HALO	RA LED Series 4" Adjustable	✓			
	RA5606_	HALO	RA LED Series 5 & 6" Adjustable	✓			
	RL460_	HALO	RL 4" LED	✓			
	RL560_	HALO	RL 5" & 6" LED	✓			
	SLD405_	HALO	SLD LED Series 4" Recessed and Surface	✓			
	SLD606_	HALO	SLD LED Series 5" & 6" Recessed and Surface	✓			
Pendant and Surface	LSR6A_	PORTFOLIO	L 6" Round Cylinder LED Series	✓			✓
	LSSQ6A_	PORTFOLIO	L 6" Square Cylinder LED Series	✓			✓
	LSR8A_	PORTFOLIO	L 8" Round Cylinder LED Series	✓			✓
	LSM_45_	PORTFOLIO	L WaveStream LED Surface/Pendant	✓			✓
Parking Garage	ODCAST1A_	LUMARK	Quadcast	coming soon	coming soon	✓	
	TT_	MCGRAW-EDISON	TopTier LED	✓	✓	✓	✓
	VPL_	MCGRAW-EDISON	VPL LED	✓	✓	✓	✓
Industrial Highbay	HBLED	METALUX	HB LED Series	✓	✓	✓	✓
Industrial Strip	SNLED	METALUX	SN LED Series	✓	✓	✓	✓

NONRESIDENTIAL INDOOR: Product Reference Guide

FEATURED NONRESIDENTIAL AMBIENT PRODUCTS



These products are recommendations based on Title 24 requirements. There are many configuration combinations available in the products listed below. Due to ever-changing nature of evolving technologies other solutions may be available in addition to the ones below.

Fixture Type	Model	Product Line	Description				
				Luminaire Dimming	Optional Daylighting Control	Optional Occupancy Sensor	Emergency Backup (for Egress)
Ambient Troffer	_AC-LD_	METALUX	Accord 1x4, 2x2, and 2x4	✓			✓
	ALN-LD	METALUX	ArcLine 1x4, 2x2, and 2x4	✓			✓
	CZ-LD	METALUX	Cruze 2x2 and 2x4	✓	✓	✓	✓
	_EN-LD	METALUX	Wavestream Encounter 1x2, 1x4, 2x2, and 2x4	✓	✓	✓	✓
	_SR-LD	METALUX	Wavestream SkyRidge 1x2, 1x4, 2x2, and 2x4	✓	✓	✓	✓
	DRI	CORELITE	Wavestream Divide 1x4, 2x2, and 2x4	✓	✓	✓	✓
	HE LED	NEO-RAY	Luminous HE LED	✓	✓	✓	✓
	R2X	CORELITE	R2X LED	✓	✓	✓	✓
	R3	CORELITE	R3 LED	✓	✓		✓
Ambient Recessed Linear	R6	CORELITE	R6 LED	✓	✓		✓
	S12	NEO-RAY	Define LED	✓	✓	✓	✓
	22DR	NEO-RAY	Series 22 LED	✓			✓
	23DR	NEO-RAY	Series 23 LED	✓			✓
Ambient Suspended	901	NEO-RAY	Index LED	✓	✓	✓	✓
	DSI	CORELITE	WaveStream Divide Suspended	✓	✓	✓	✓
	J2	CORELITE	J2 LED	✓	✓	✓	✓
	L2	CORELITE	L2 LED	✓	✓	✓	✓
	RZL	CORELITE	RZL LED	✓	✓	✓	✓
Ambient Wall Bracket	DW1	CORELITE	WaveStream Divide Wall LED	✓	✓	✓	✓
	L1W	CORELITE	L1 Wall LED	✓	✓	✓	✓
Ambient Indirect Cove	0-08	IO	Raye LED	✓			

NONRESIDENTIAL INDOOR: Product Reference Guide

FEATURED NONRESIDENTIAL EXIT AND EGRESS PRODUCTS

These products are recommendations based on Title 24 requirements. There are many configuration combinations available in the products listed below. Due to ever-changing nature of evolving technologies other solutions may be available in addition to the ones below.

Fixture Type	Model	Product Line	Description	T20 Certified		
					Luminaire Dimming	Emergency Backup (for Egress)
Emergency Lighting	APEL	Sure-Lites	Two heads LED			✓
	AP2SQ_	Sure-Lites	Two heads LED			✓
	APR_	Sure-Lites	Remote heads LED			✓
	AEL2_	Sure-Lites	Diecast surface mount architectural			✓
	CEL_	Sure-Lites	Recessed concealed twin head			✓
	RLM_	Sure-Lites	Recessed twin head			✓
	STL2_	Sure-Lites	Linear surface mount			✓
	AA1_	Sure-Lites	Commercial two heads			✓
	CC2_	Sure-Lites	Contractor choice twin head			✓
	CU2	Sure-Lites	Contemporary twin head			✓
	LEM_	Sure-Lites	Miniature LED twin remote head			✓
Emergency Exit	APX7_	Sure-Lites	Battery backup	✓		✓
	CX7_	Sure-Lites	Diecast battery backup	✓		✓
	LPX7_	Sure-Lites	Battery backup	✓		✓
	SLX7_	Sure-Lites	Battery backup	✓		✓
Exit	APX6x	Sure-Lites	AC powered	✓		✓
	CX6_	Sure-Lites	Diecast AC powered	✓		✓
	LPX6_	Sure-Lites	AC powered	✓		✓
	SLX6_	Sure-Lites	AC powered	✓		✓

NONRESIDENTIAL INDOOR: Controls Reference Guide

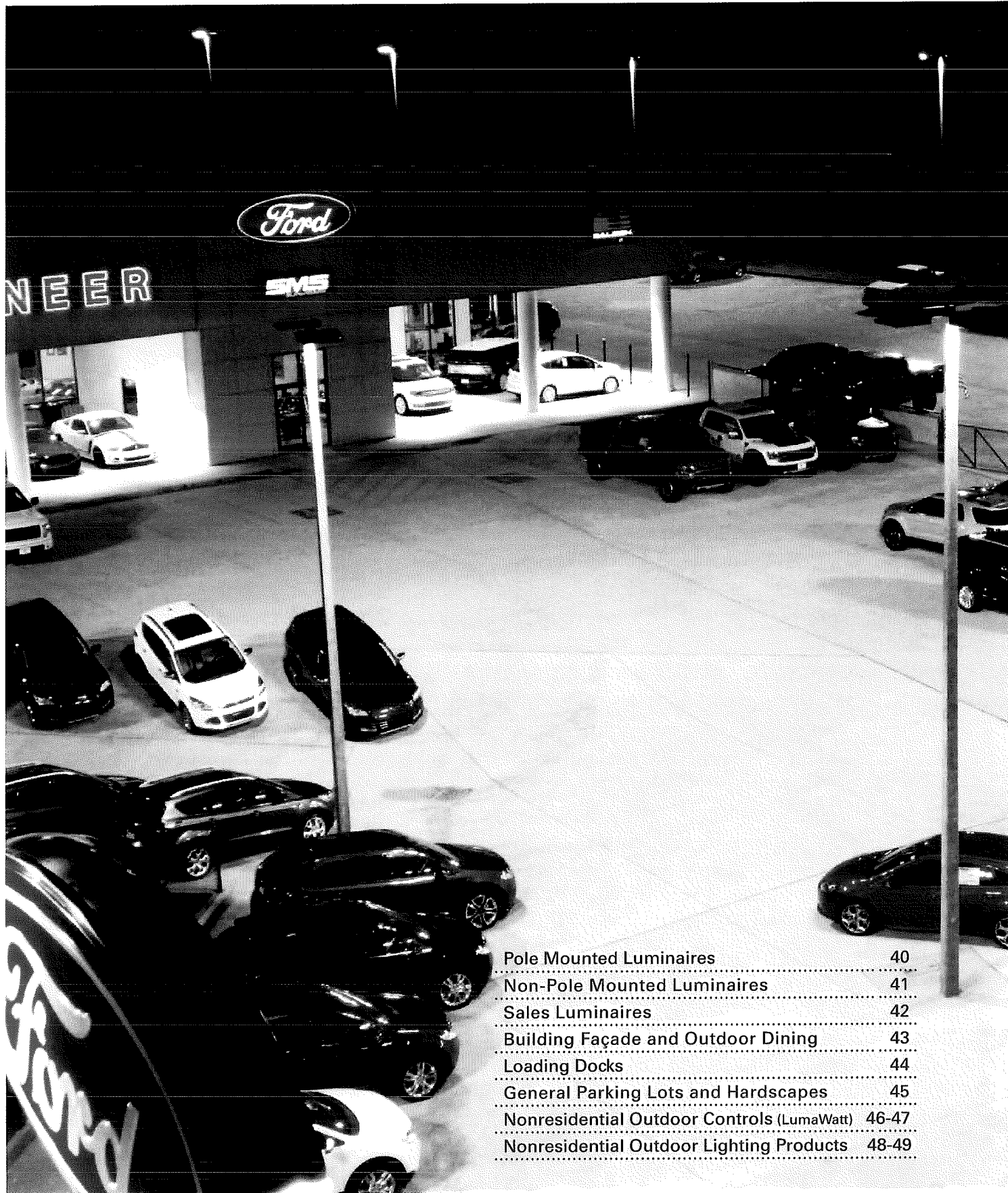
FEATURED NONRESIDENTIAL CONTROL PRODUCTS

The controls listed below are designed to meet the code requirements of Title 24. These products are easy to utilize in the design planning and commissioning phases of the project to meet the space requirements of multi-level lighting control, shut-off control, and daylighting. For assistance to select the right product, consult with your Eaton lighting solutions representative.

Header	Control Type	Model	Description
Addressable	DALI Mobile Software	FLT-iBuilding-iPhone	iPhone app for DALI control
	DALI Multi-Sensor	FLT-MTS_	Digital Programmable Sensor for occupancy, temperature, and daylighting
	DALI Touch Screen	FLT-TS_	Digital Programmable Touch Screen for graphical control
	DALI Wallstation	FDW_	Digital Programmable Wallstation for ON/OFF, dimming and scene presets
	DALI Wallstation	FLT-LVD_	Low Voltage programmable wallstation for ON/OFF, dimming and scene presets
	VOIP Lighting Software	FLT-VOIP	VOIP software DALI control telephone
Occupancy and Vacancy Sensors	High-Bay Occupancy Sensor	OEP-P-2MH0-MV-S	Line Voltage PIR luminaire-mount sensor ON/OFF function
	Occupancy and Daylight Sensor	OXC-P_	Extreme temperature Low Voltage PIR sensor with photocell
	Occupancy Ceiling Sensor	OAC-P_	Low Voltage PIR ceiling sensor with daylight sensing
		OAC-U_	Low Voltage Ultrasonic ceiling sensor with daylight sensing
		OAC-DT_	Low Voltage dual tech PIR and Ultrasonic ceiling sensor with daylight sensing
	Vacancy Ceiling Sensor	OAC-DT_MV	Line Voltage dual tech PIR and Ultrasonic ceiling sensor with daylight sensing
		VAC-P_	Low Voltage PIR ceiling sensor with daylight sensing
		VAC-U_	Low Voltage Ultrasonic ceiling sensor with daylight sensing
		VAC-DT_	Low Voltage dual tech PIR and Ultrasonic ceiling sensor with daylight sensing
	Wall/Corner Occupancy Sensor	OAWC-DT_	Low Voltage dual tech PIR and Ultrasonic wall or corner mount occupancy sensor
Switchpack	Relay Switchpack	SPD20-MV-NO	Line Voltage dual relay control for use with Low Voltage sensors
	Relay Switchpack	SP_MV	Heavy duty Line Voltage relay control for use with Low Voltage sensors
Room Based	Room Controller Main	RC3D/RC3DE	Main controller for dimming, occupancy/vacancy and manual switching*
	Room Controller Dimming Slider	RC-SS1_	0-10V dimming slider
	Room Controller Open Loop Sensor	DSRC-FMOIR	Daylight Sensor / IR receiver
	Room Controller Receptacle Control	SPRC-R-20-120	20A ON/OFF receptacle rated switchpack
	Room Controller Scene Wallstation	RC_T_B-P_	Low voltage ON/OFF and dimming loads
	Room Controller Wallstation	RC_T_B_	Low voltage ON/OFF and dimming loads
Stand Alone Daylighting	Daylight Controller	DLC-PDC	ON/OFF switching
	Outdoor Photosensor	PPS-5	ON/OFF switching
	Photocontrol	PC_	Analog Photosensor
		DLC-PD_	Analog Photosensor
	Photodiode	DLC-PD-DIM	Continuous dimming with occupancy with ON/OFF
Wallbox	Switch Wallstation	DF10P-C_	0-10V decorator style dimmer with ON/OFF switching
		SF10P_	0-10V slide style dimmer with ON/OFF switching
		G5_ / G20_	ON/OFF switching
	Wall Occupancy Sensor Switch	ONW-D-1001-(D)MV_	Single or dual level switch dual tech PIR and Ultrasonic occupancy sensor
		ONW-D_MV_	Low voltage switch dual tech PIR and Ultrasonic occupancy sensor
	Wall Vacancy Sensor Switch	ONW-D_SP_	Single or dual level switch dual tech PIR and Ultrasonic occupancy sensor
	Wall Timer Switch	TSW-MV_	Digital wall count-down timer switch

*RC3_ controller can be paired with all Eaton lighting products.

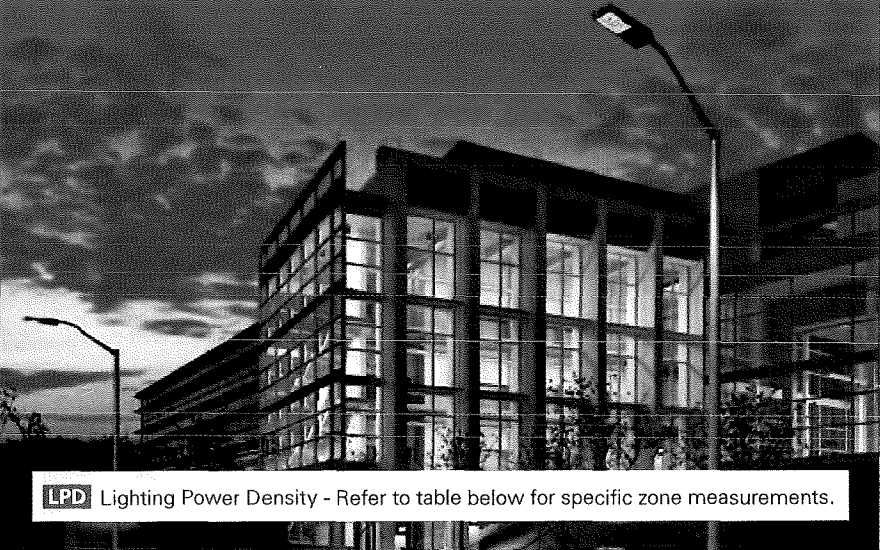
Nonresidential Outdoor Applications





SPACE ASSUMPTIONS

- Pole Mounted 24 feet or less
- Luminaires not part of health safety statute, ordinances, regulations, on public right of way on public maintained roadways, sidewalks and bikeways
- Temporary lighting excluded
- Greater than 75 watts



LPD Lighting Power Density - Refer to table below for specific zone measurements.

CUTOFF (UPLIGHT AND GLARE)

- Refer to replacements of existing pole mounted luminaires for further exceptions
- Exception: Cutoff not required if 150W or less



Zonal Lumen Requirements

Reference:

See 1D-114-A page 37 and Tables 130.2-A and B pages 147-148

AREA CONTROL

- 1500 watts is the maximum allowed when controlled together
- Exception: If mounted >24 feet there is no limit on wattage controlled together



Maximum Wattage Controlled Together

Reference:

See 130.2(c) pages 146-147

MULTI-LEVEL LIGHTING AND SHUTOFF CONTROL

- Luminaire must provide dimming sufficiently to meet the shutoff requirements
- One dimming step or continuous dimming between 40% and 80% power when vacant. Full ON when occupied.

Exception: Controls not required if mounted >24 feet or luminaire is rated for 75 watts maximum



Luminaire Dimming



Occupancy Sensor

Reference:

See 130.2(c) pages 146-147

AUTOMATIC DAYLIGHTING CONTROL

Exception: Tunnels required to be illuminated 24 hours and 365 days per year. On/Off control at sunrise and sunset.



Photocontrol



Automatic (Astronomical) Time Switch

(CHOOSE ONE OR MORE)

Reference:

See 130.2(c) pages 146-147

LIGHTING ENERGY BUDGET

	LPD Lighting Power Density			
Lighting Zones:	Zone 1	Zone 2	Zone 3	Zone 4
Area Wattage Allowance (AWA) [watts per square foot]	0.035	0.045	0.090	0.115
Linear Wattage Allowance (LWA) [watts per linear foot]	0.25	0.45	0.60	0.85
Initial Wattage Allowance (IWA) [wattage]	340	510	770	1,030

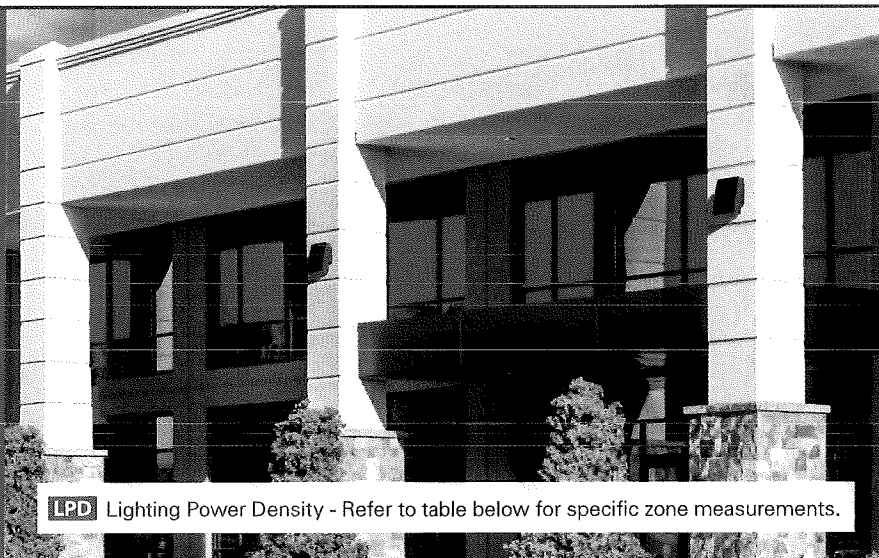
*Additions can be added to the total budget where they apply.

Reference:

Table 140.7-A&B pages 195-197 for additional power allowances by specific applications.*

SPACE ASSUMPTIONS

- Non-Pole Mounted including Wall Mounted and Bollards as examples
- Mounted 24 feet or less
- Luminaires not part of health safety statute, ordinances, regulations, on public right of way on public maintained roadways, sidewalks and bikeways
- Temporary lighting excluded
- Greater than 30 watts



CUTOFF (UPLIGHT AND GLARE)

Exception: Cutoff not required if 150W or less



Zonal Lumen
Requirements

Reference:

See 1D-114-A
page 37 and Tables
130.2-A and B
pages 147-148

AREA CONTROL

- 1500 watts is the maximum allowed when controlled together

Exception: If mounted >24 feet there is no limit on wattage controlled together



Maximum Wattage
Controlled Together

Reference:

See 130.2(c)
pages 146-147

MULTI-LEVEL LIGHTING AND SHUTOFF CONTROL

- Luminaire must provide dimming sufficiently to meet the shutoff requirements.
- One dimming step or continuous dimming between 40% and 80% power when vacant. Full ON when occupied.

Exception: Controls not required if mounted >24 feet or luminaire is rated for 30 watts maximum.



Luminaire
Dimming



Occupancy
Sensor

Reference:

See 130.2(c)
pages 146-147

AUTOMATIC DAYLIGHTING CONTROL

Exception: Tunnels required to be illuminated 24 hours and 365 days per year. On/Off control at sunrise and sunset.



Photocontrol



Automatic
(Astronomical)
Time Switch

(CHOOSE ONE OR MORE)

Reference:

See 130.2(c)
pages 146-147

LIGHTING ENERGY BUDGET

LPD Lighting Power Density

Lighting Zones:	Zone 1	Zone 2	Zone 3	Zone 4
Area Wattage Allowance (AWA) [watts per square foot]	0.035	0.045	0.090	0.115
Linear Wattage Allowance (LWA) [watts per linear foot]	0.25	0.45	0.60	0.85
Initial Wattage Allowance (IWA) [wattage]	340	510	770	1,030

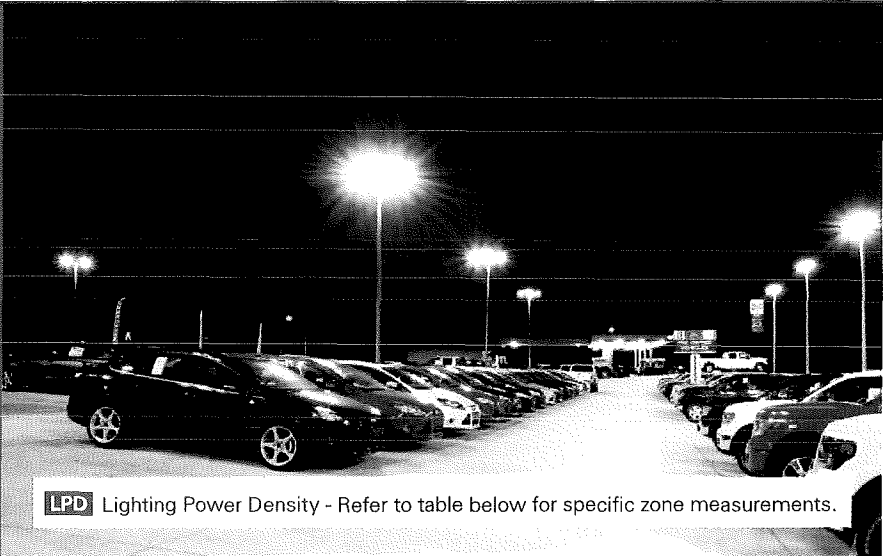
*Additions can be added to the total budget where they apply.

Reference:

Table 140.7-A&B
pages 195-197
for additional
power allowances
by specific
applications.*

SPACE ASSUMPTIONS

- Outdoor Sales Luminaires such as Sales Frontage, Sales Lots, and Sales Canopies
- Luminaires not part of health safety statute, ordinances, regulations, on public right of way on public maintained roadways, sidewalks or bikeways
- Temporary lighting excluded
- Greater than 150 watts



LPD Lighting Power Density - Refer to table below for specific zone measurements.

CUTOFF (UPLIGHT AND GLARE)

- Refer to replacements of existing pole mounted luminaires for further exceptions
- Exception: Cutoff not required if 150W or less



Zonal Lumen Requirements

Reference:
See 1D-114-A
page 37 and Tables
130.2-A and B
pages 147-148

AREA CONTROL

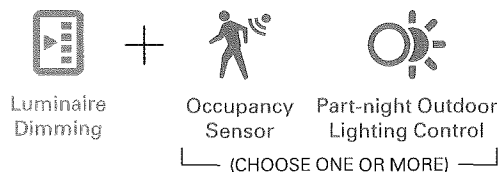
- None required

AREA CONTROL NOT REQUIRED FOR
SALES LUMINAIRE APPLICATIONS

Reference:
See 130.2(c)
pages 146-147

MULTI-LEVEL LIGHTING AND SHUTOFF CONTROL

- Luminaire must provide dimming sufficiently to meet the shutoff requirements
- One dimming step or continuous dimming between 40% and 80% power when vacant. Full ON when occupied.
- Part-night Outdoor Lighting Control reduces power or turns off luminaire for a portion of the night



Reference:
See 130.2(c)
pages 146-147

AUTOMATIC DAYLIGHTING CONTROL

Exception: Tunnels required to be illuminated 24 hours and 365 days per year. On/Off control at sunrise and sunset.



Reference:
See 130.2(c)
pages 146-147

LIGHTING ENERGY BUDGET

LPD Lighting Power Density

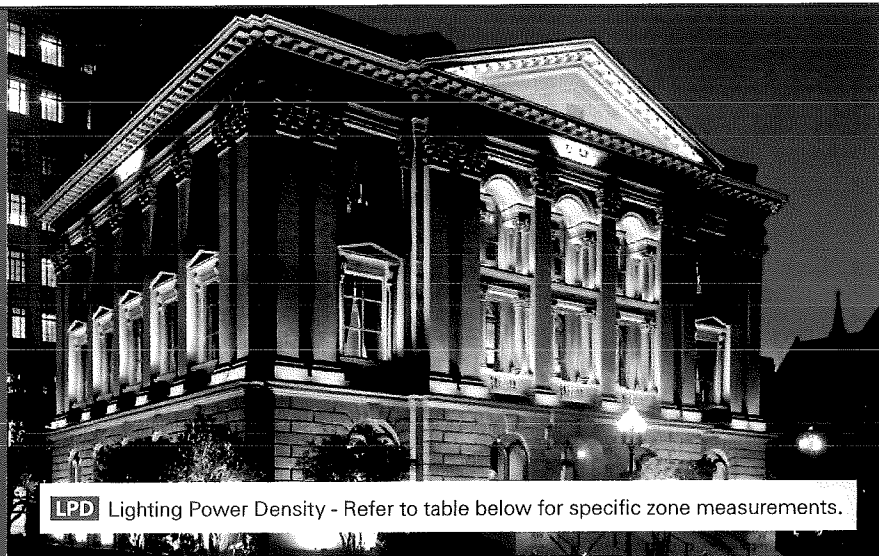
Lighting Zones:	Zone 1	Zone 2	Zone 3	Zone 4
Area Wattage Allowance (AWA) [watts per square foot]	0.035	0.045	0.090	0.115
Linear Wattage Allowance (LWA) [watts per linear foot]	0.25	0.45	0.60	0.85
Initial Wattage Allowance (IWA) [wattage]	340	510	770	1,030

*Additions can be added to the total budget where they apply.

Reference:
Table 140.7-A&B
pages 195-197
for additional
power allowances
by specific
applications.*

SPACE ASSUMPTIONS

- Building Façade and Outdoor Dining
- Luminaires not part of health safety statute, ordinances, regulations, on public right of way on public maintained roadways, sidewalks and bikeways
- Temporary lighting excluded
- Greater than 150 watts



CUTOFF (UPLIGHT AND GLARE)

- Refer to replacements of existing pole mounted luminaires for further exceptions.
- Outdoor wall mounted luminaires must have a bilaterally symmetric distribution.

Exception: Cutoff not required if 150W or less



Zonal Lumen Requirements

Reference:
See 1D-114-A
page 37 and Tables
130.2-A and B
pages 147-148

AREA CONTROL

- None required

AREA CONTROL NOT REQUIRED FOR
BUILDING FAÇADE AND OUTDOOR DINING APPLICATIONS

Reference:
See 130.2(c)
pages 146-147

MULTI-LEVEL LIGHTING AND SHUTOFF CONTROL

- Luminaire must provide dimming sufficiently to meet the shutoff requirements
- One dimming step or continuous dimming between 40% and 80% power when vacant. Full ON when occupied.
- Part-night Outdoor Lighting Control reduces power or turns off luminaire for a portion of the night



Luminaire Dimming



Occupancy Sensor



Part-night Outdoor Lighting Control

(CHOOSE ONE OR MORE)

Reference:
See 130.2(c)
pages 146-147

AUTOMATIC DAYLIGHTING CONTROL

- On/Off control at sunrise and sunset.



Photocontrol



Automatic (Astronomical) Time Switch

(CHOOSE ONE OR MORE)

Reference:
See 130.2(c)
pages 146-147

LIGHTING ENERGY BUDGET

	LPD Lighting Power Density			
Lighting Zones:	Zone 1	Zone 2	Zone 3	Zone 4
Area Wattage Allowance (AWA) [watts per square foot]	0.035	0.045	0.090	0.115
Linear Wattage Allowance (LWA) [watts per linear foot]	0.25	0.45	0.60	0.85
Initial Wattage Allowance (IWA) [wattage]	340	510	770	1,030

*Additions can be added to the total budget where they apply.

Reference:
Table 140.7-A&B
pages 195-197
for additional
power allowances
by specific
applications.*

SPACE ASSUMPTIONS

- Non-pole mounted no more than 24 feet
- Luminaires not part of health safety statute, ordinances, regulations, on public right of way on public maintained roadways, sidewalks and bikeways
- Temporary lighting excluded
- Greater than 30 watts
- Refer to OSHA guidelines since special considerations could alter the requirements



LPD Lighting Power Density – Refer to table below for specific zone measurements.

CUTOFF (UPLIGHT AND GLARE)

- Refer to replacements of existing pole mounted luminaires for further exceptions
- Exception: Cutoff not required if 150W or less



Zonal Lumen
Requirements

Reference:
See 1D-114-A
page 37 and Tables
130.2-A and B
pages 147-148

AREA CONTROL

- 1500 watts is the maximum allowed when controlled together
- Exception: If mounted >24 feet there is no limit on wattage controlled together



Maximum Wattage
Controlled Together

Reference:
See 130.2(c)
pages 146-147

MULTI-LEVEL LIGHTING AND SHUTOFF CONTROL

- Luminaire must provide dimming sufficiently to meet the shutoff requirements
 - One dimming step or continuous dimming between 40% and 80% power when vacant. Full ON when occupied.
- Exception: Controls not required if mounted >24 feet or luminaire is rated for 30 watts maximum



Luminaire
Dimming



Occupancy
Sensor

Reference:
See 130.2(c)
pages 146-147

AUTOMATIC DAYLIGHTING CONTROL

Exception: On/Off control at sunrise and sunset



Photocontrol



Automatic
(Astronomical)
Time Switch

(CHOOSE ONE OR MORE)

Reference:
See 130.2(c)
pages 146-147

LIGHTING ENERGY BUDGET

LPD Lighting Power Density

Lighting Zones:	Zone 1	Zone 2	Zone 3	Zone 4
Area Wattage Allowance (AWA) [watts per square foot]	0.035	0.045	0.090	0.115
Linear Wattage Allowance (LWA) [watts per linear foot]	0.25	0.45	0.60	0.85
Initial Wattage Allowance (IWA) [wattage]	340	510	770	1,030

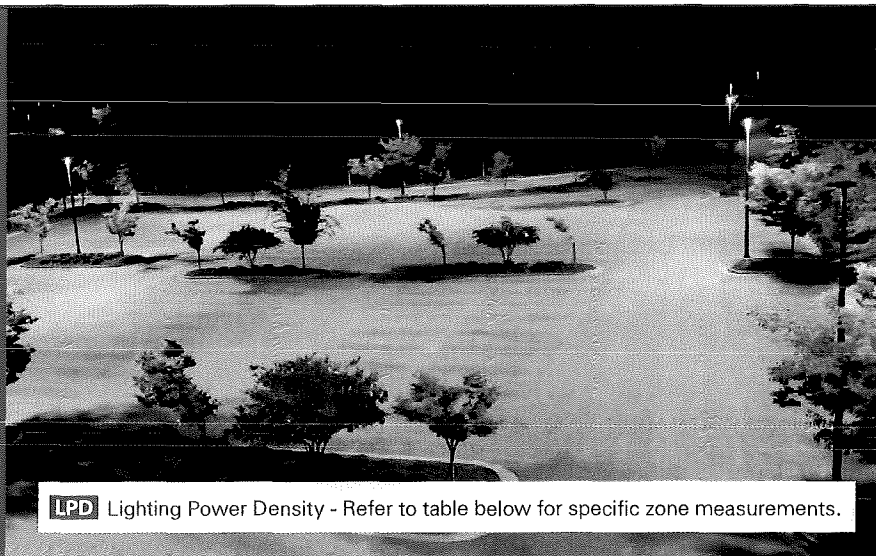
*Additions can be added to the total budget where they apply.

Reference:
Table 140.7-A&B
pages 195-197
for additional
power allowances
by specific
applications.*

NONRESIDENTIAL OUTDOOR: General Parking Lots and Hardscapes Title 24 Requirements

SPACE ASSUMPTIONS

- Hardscapes and general parking lots which includes the top deck of parking garages
- Mounting height greater than 24 feet
- Luminaires not part of health safety statue, ordinances, regulations, on public right of way on public maintained roadways, sidewalks and bikeways
- Temporary lighting excluded
- Greater than 150 watts



LPD Lighting Power Density - Refer to table below for specific zone measurements.

CUTOFF (UPLIGHT AND GLARE)

- Refer to replacements of existing pole mounted luminaires for further exceptions.
- Outdoor wall mounted luminaires must have a bilaterally symmetric distribution.

Exception: Cutoff not required if 150W or less



Zonal Lumen Requirements

Reference:
See 1D-114-A
page 37 and Tables
130.2-A and B
pages 147-148

AREA CONTROL

- None required

Exception: Area control required when luminaires are mounted 24 feet or less; luminaires at this height must have no more than 1,500 watts controlled together

AREA CONTROL NOT REQUIRED FOR
GENERAL PARKING LOTS AND HARDSCAPES
IF MOUNTING HEIGHT OVER 24 FEET

Reference:
See 130.2(c)
pages 146-147

MULTI-LEVEL LIGHTING AND SHUTOFF CONTROL

- No multi-level or shutoff control is required

Exception:

- Part-night Outdoor Lighting control are used in outdoor sales frontage, sales lots, sales canopies, building facade, ornamental hardscape, and outdoor dining
- If mounted 24 feet or less, and greater than 75 watts if pole mounted or 30 watts if non-pole mounted, an occupancy sensor is required

MULTI-LEVEL LIGHTING AND SHUTOFF CONTROL NOT REQUIRED
FOR GENERAL PARKING LOTS AND HARDSCAPES

Reference:
See 130.2(c)
pages 146-147

AUTOMATIC DAYLIGHTING CONTROL

- On/Off control at sunrise and sunset.



Photocontrol



Automatic
(Astronomical)
Time Switch

(CHOOSE ONE OR MORE)

Reference:
See 130.2(c)
pages 146-147

LIGHTING ENERGY BUDGET

	LPD Lighting Power Density			
Lighting Zones:	Zone 1	Zone 2	Zone 3	Zone 4
Area Wattage Allowance (AWA) [watts per square foot]	0.035	0.045	0.090	0.115
Linear Wattage Allowance (LWA) [watts per linear foot]	0.25	0.45	0.60	0.85
Initial Wattage Allowance (IWA) [wattage]	340	510	770	1,030

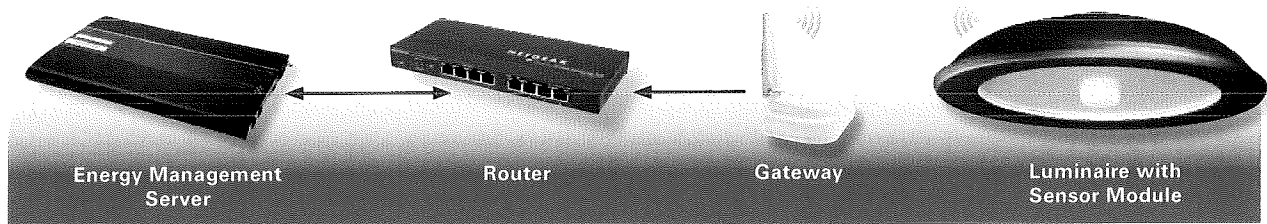
*Additions can be added to the total budget where they apply.

Reference:
Table 140.7-A&B
pages 195-197
for additional
power allowances
by specific
applications.*

NONRESIDENTIAL OUTDOOR CONTROLS: LumaWatt System

LUMAWATT LIGHTING MANAGEMENT AND CONTROL SYSTEM

The heart and soul of Title 24 is lighting management and control – to minimize power consumption and energy costs by providing the right light levels where and when they're needed. The **LumaWatt Outdoor Wireless Control System** makes implementation easy offering standard features that satisfies California Title 24 requirements. The LumaWatt system integrates sensors, reducing installation costs and commissioning time. Multi-functional sensors are factory-installed and tested in each luminaire so reliability, area coverage and location are never concerns.



The LumaWatt system is a peer-to-peer wireless network of luminaire-integrated sensors, which operate in accordance with stored programmable profiles. Each sensor is capable of motion and photo sensing, metering power consumption and wireless communication.

BUILT-IN CODE COMPLIANCE

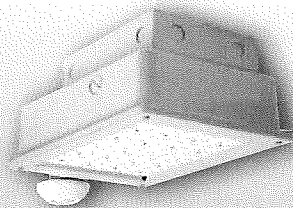
The LumaWatt system commissioning enables code compliance for Indoor and Outdoor requirements.

The products shown below are popular luminaires compatible with LumaWatt.

Indoor Integrated Luminaires



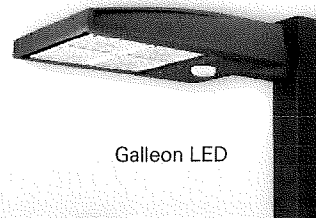
TopTier LED



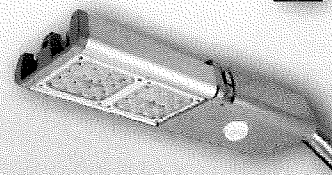
Valet LED

Reference: Section 130.1, "Indoor Lighting Controls That Shall Be Installed", applies to spaces including Parking Garages requiring area-control, multi-level lighting, shutoff control and daylighting.

Outdoor Integrated Luminaires



Galleon LED



Navion LED

Reference: Section 130.2, "Outdoor Lighting Controls and Equipment", applies to spaces including hardscapes like a parking lot where requirements like photocontrol, motion sensing, dimming, and part-night are required.

LUMINAIRES USING THE LUMAWATT SYSTEM EXCEED CALIFORNIA TITLE 24 REQUIREMENTS:

An additional 30%-50% reduction of energy use is common as a result of integrating basic lighting control strategies to efficient LED luminaires.

NONRESIDENTIAL OUTDOOR CONTROLS: LumaWatt System




THE LUMAWATT SYSTEM EXCEEDS CALIFORNIA TITLE 24 REQUIREMENTS IN THE FOLLOWING AREAS:

	 Indoor	 Outdoor
CUTOFF (UPLIGHT AND GLARE)	<p>Cutoff not applicable to indoor applications</p>	<p>Eaton offers a broad range of LumaWatt integrated outdoor luminaires such as the McGraw-Edison Navion that reliably meet the cutoff code requirements identified in the various Lighting Zones found in TABLES 130.2-A and 130.2-B.</p> <p>Reference: 130.2(b) page 146</p>  <p>Zonal Lumen Requirements</p>
AREA CONTROL	<p>Manual switch can communicate a wireless signal to the luminaire-integrated LumaWatt sensors to turn off the luminaires.</p> <p>Reference: 130.1(a) page 140</p>  <p>Manually Switched ON/OFF</p>	<p>LumaWatt integrated outdoor luminaires mounted 24 feet or less are easily commissioned to be controlled wirelessly together to satisfy the maximum wattage within a control group of 1500W. This capability assures that all outdoor lighting is controlled independently from other electrical loads.</p> <p>Reference: 130.2(c) pages 146-147</p>  <p>1500 Maximum Wattage Controlled Together</p>
MULTI-LEVEL LIGHTING	<p>Eaton parking garage luminaires like the McGraw-Edison TopTier feature multi-level lighting continuous dimming capabilities. The sensors respond to signals to continuously dim to the commissioned level.</p> <p>Reference: 130.1(b) page 140-141</p>      	<p>Luminaires like the McGraw-Edison Galleon site luminaire come with continuous multi-level leveling lighting continuous dimming capabilities. The LumaWatt sensors will respond to signals to continuously dim to the commissioned level.</p> <p>Reference: 130.2(c) pages 146-147</p>  <p>Luminaire Dimming</p>
SHUTOFF CONTROL	<p>The LumaWatt luminaire-integrated sensor includes an occupancy sensor at each luminaire. In addition, time-switching and remote signals can be received to satisfy multiple requirements for the intended use to meet code requirements.</p> <p>Reference: 130.1(c) page 141-143</p>  <p>Occupancy Sensor</p>	<p>Whether occupancy sensing, part-night control or both are needed for the application, the LumaWatt integrated control system meets the code requirements simply during the commissioning process.</p> <p>Reference: 130.2(c) pages 146-147</p>   <p>Occupancy Sensor Luminaire Dimming</p>  <p>Part-night Outdoor Lighting Control</p>
AUTOMATIC DAYLIGHTING CONTROL	<p>Daylighting capabilities comes standard with the LumaWatt luminaire-integrated sensor. LumaWatt commissioning is simple to address the needs of Skylit and Sidelit Daylit Zones for the space at each luminaire simplifying light level requirements for each discrete luminaire complying with the code requirements.</p> <p>Reference: 130.1(d) page 143-144</p>   <p>Luminaire Dimming Daylighting Control</p>	<p>Photocontrols or astronomical time-switch are essential to meet the code requirements of which the LumaWatt exceeds the requirements by offering both via wirelessly. The precise integrated LumaWatt sensor coupled with the Energy Management Server assures the luminaires turn on and off during the nighttime hours incorporating additional time schedules as needed.</p> <p>Reference: 130.2(c) pages 146-147</p>   <p>Photocontrol Automatic (Astronomical) Time Switch</p>
ADDITIONAL FEATURES	<p>The LumaWatt Energy Management Server can receive commands for a DR event. These command are then programmed to reduce the wattage by 15% or more consistent with uniform level of illumination requirements found in TABLE 130.1-A. This capability allows for power factor adjustment to the lighting power density.</p> <p>Reference: 130.1(e) page 144</p>  <p>LPD Lighting Power Density</p>	<p>The LumaWatt system incorporates the photocontrol, time-switch control, motion sensing, power reduction, part-night control, and auto-ON functionality. This comprehensive set of features using the luminaire-integrated sensor along with the Energy Management Server operates luminaires installed at any height to satisfying code requirements in one comprehensive solution.</p> <p>Reference: 130.2(c) pages 146-147</p>   <p>Reporting Monitoring</p>

NONRESIDENTIAL OUTDOOR: Product Reference Guide

FEATURED NONRESIDENTIAL OUTDOOR LIGHTING PRODUCTS

These products are recommendations based on Title 24 requirements. There are many configuration combinations available in the products listed below. Due to ever-changing nature of evolving technologies other solutions may be available in addition to the ones below.




Fixture Type	Model	Product Line	Description			
				Luminaire Dimming	Integral Occupancy Sensor	Integral Photocontrol Sensor
Canopy	CNC_	MCGRRAW-EDISON	Concise - Surface Mount LED	✓	✓	✓
	LRC_	MCGRRAW-EDISON	LRC - Recessed LED	✓		✓
Decorative	ACN_	STREETWORKS	Generation Series - Traditional LED	✓		✓
	ARC_	STREETWORKS	Generation Series - Traditional LED	✓		✓
	CEL_	STREETWORKS	Classical Epic - LED	✓	✓	✓
	CEM_	STREETWORKS	Classical Epic - LED	✓	✓	✓
	CLB_	STREETWORKS	Generation Series - Traditional LED	✓		✓
	ECL_	INVUE	Epic Large - LED	✓	✓	✓
	ECM_	INVUE	Epic Medium - LED	✓	✓	✓
	EML_	INVUE	Epic Large - LED	✓	✓	✓
	EMM_	INVUE	Epic Medium - LED	✓	✓	✓
	GAR_	MCGRRAW-EDISON	Generation Series - Traditional LED	✓		✓
	GAT_	MCGRRAW-EDISON	Generation Series - Traditional LED	✓		✓
	GLC_	MCGRRAW-EDISON	Generation Series - Traditional LED	✓		✓
	MEL_	STREETWORKS	Modern Epic Large - LED	✓	✓	✓
	MEM_	STREETWORKS	Modern Epic Medium - LED	✓	✓	✓
	MPW_	STREETWORKS	Woodbridge - LED	✓		✓
	MSA_	INVUE	Mesa - LED	✓	✓	✓
	PMM_	STREETWORKS	Mesa - LED	✓		✓
	UTLD_	STREETWORKS	UTLD Traditionaire - LED	✓		✓
	UTR_	STREETWORKS	UTR Traditionaire - LED	✓		✓
Flood	MAQ_	MCGRRAW-EDISON	Marquis - LED	✓		✓
	NFFLD_	LUMARK	Night Falcon - LED	✓	✓	✓
	UFLD_	STREETWORKS	Utility Flood - LED	✓	✓	✓
	VFS_	INVUE	Vision Flood Small - LED	✓		✓

Pole Mounted and Wall Mounted products on following page

NONRESIDENTIAL OUTDOOR: Product Reference Guide

FEATURED NONRESIDENTIAL OUTDOOR LIGHTING PRODUCTS

These products are recommendations based on Title 24 requirements. There are many configuration combinations available in the products listed below. Due to ever-changing nature of evolving technologies other solutions may be available in addition to the ones below.

Fixture Type	Model	Product Line	Description	 Luminaire Dimming	 Integral Occupancy Sensor	 Integral Photocontrol Sensor
Pole Mounted	AVM_	STREETWORKS	Vision Site Medium - Area LED	✓		✓
	AVS_	STREETWORKS	Vision Site Small - Area LED	✓		✓
	CRTK-A_	STREETWORKS	Caretaker - Area LED	Not required if <75W		✓
	CTKRV1A_	LUMARK	Caretaker - Area/Site LED	Not required if <75W		✓
	GAN_	STREETWORKS	Galleon - Area LED	✓	✓	✓
	GLEON_	MCGRAW-EDISON	Galleon - Area Roadway LED	✓	✓	✓
	ICM_	INVUE	Icon Site - Area Roadway LED	✓	✓	✓
	LDRC_	LUMARK	Small Cobrahead - Area/Site LED			✓
	LDRL_	LUMARK	Large Cobrahead - Area/Site LED			✓
	LDRV_	LUMARK	Ridgeview - Area/Site LED	✓	✓	✓
	NAV_	LUMARK	Navion - Area/Site LED	✓	✓	✓
	NVN_	STREETWORKS	Navion - Roadway LED	✓	✓	✓
	OVF_	STREETWORKS	Large Cobrahead - Roadway LED	✓		✓
	OVH_	STREETWORKS	OVH - Roadway LED	✓		✓
	RDG_	STREETWORKS	Ridgeview - Area LED	✓	✓	✓
	SDM_	INVUE	Slide Site - Area Roadway LED	✓	✓	✓
	TLM_	MCGRAW-EDISON	Talon Medium - Area Roadway LED	✓		✓
	TMU_	STREETWORKS	Talon - Area LED	✓		✓
	VERD_	STREETWORKS	Verdeon - Roadway LED	✓	✓	✓
	VST_	STREETWORKS	Ventus - Area LED	✓	✓	✓
	VTS_	MCGRAW-EDISON	Ventus - Area Roadway LED	✓	✓	✓
	VXM_	INVUE	Vision Site Medium - Area Roadway LED	✓	✓	✓
	VXS_	INVUE	Vision Site Medium - Area Roadway LED	✓	✓	✓
	XNV_	STREETWORKS	XNV - Roadway LED	✓	✓	✓
Wall Mounted	ENC_	INVUE	Entri Round Clean - LED	✓	✓	✓
	ENT_	INVUE	Entri Triangle Reveals - LED	✓	✓	✓
	ENV_	INVUE	Entri Round Reveals - LED	✓	✓	✓
	ISC_	MCGRAW-EDISON	Impact Elite Cylinder - LED	✓	✓	✓
	ISS_	MCGRAW-EDISON	Impact Elite Quarter Sphere - LED	✓	✓	✓
	IST_	MCGRAW-EDISON	Impact Elite Trapezoid - LED	✓	✓	✓
	ISW_	MCGRAW-EDISON	Impact Elite Wedge - LED	✓	✓	✓
	LDWP_	LUMARK	Wal-Pak - LED	✓		✓
	WKP_	STREETWORKS	Wal-Pak - LED	✓		✓
	XTOR	LUMARK	Crosstour - LED	✓	✓	✓

Residential Applications



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Controlled, efficient lighting offers both comfort and lower electric bills. Homeowners no longer have to sacrifice the quality of their home lighting to save energy.

The code utilizes two categories of luminaires: "High Efficacy" and "Low Efficacy".

"High Efficacy" and "Low Efficacy" luminaires must be circuited separately. "High Efficacy" luminaires are favored and generally do not require controls beyond a manual ON/OFF switch, whereas "Low Efficacy" luminaires typically require additional controls such as dimming and vacancy sensors.



KITCHEN

Lighting circuits within the kitchen area are included

High Efficacy Luminaires

≥50% wattage must be "High Efficacy"

Low Efficacy Luminaires

≤ 50% wattage can be "Low Efficacy"

- Internal cabinet illumination must not exceed ≤ 20W / linear foot. Refer to code for calculation methods.

Reference:

See 150.0(k)(3) page 218

BATHROOMS

Sinks, toilets, shower and tub

High Efficacy Luminaires

At least one luminaire must be "High Efficacy"

Low Efficacy Luminaires

Remaining luminaires can be "Low Efficacy" controlled by a vacancy sensor

Reference:

See 150.0(k)(5) page 218

LAUNDRY ROOMS AND UTILITY ROOMS

Attached laundry rooms and utility rooms

High Efficacy Luminaires

All must be "High Efficacy" and controlled by a vacancy sensor

Low Efficacy Luminaires

None

- Consider use of dual technology, IR and ultrasound, in large rooms such as garages where the potential of low motion can turn off the lighting

Reference:

See 150.0(k)(6) page 218

OTHER ROOMS

Hallways, dining rooms, family rooms, home offices, bedrooms, attic spaces, and closets

Exceptions: Closets <70 sf and detached buildings <1000sf

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy" controlled by dimmers or vacancy sensors

- Portable lighting must be T20 certified

Reference:

See 150.0(k)(7) page 218

OUTDOOR

Includes all outdoor lighting circuits

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy" controlled by ON/OFF switch, motion sensor and one of the following: photocontrol, astronomical time clock or EMCS

- Optional types in area includes "High Efficacy" OR "Low Efficacy" using T20 photocell or T20 astronomical time clock or energy management control system (EMCS)
- Does not apply to 8 parking spots or more in a garage or parking lot. Refer to nonresidential in this case.

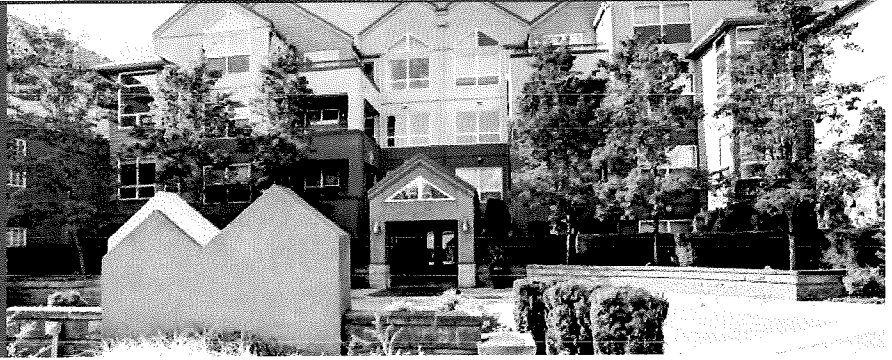
Reference:

See 150.0(k)(9) page 219

Multi-family homes, 3 stories or less, are administered much like single family. The dwelling spaces are covered under residential compliance.

The percentage of the common floor space separates when the common areas are treated under the nonresidential compliance requirements.

"High Efficacy" and "Low Efficacy" are to be separately switched with readily accessible manual ON/OFF control.



KITCHEN

Lighting circuits within the kitchen area are included

High Efficacy Luminaires

≥50% wattage must be
"High Efficacy"

Low Efficacy Luminaires

≤ 50% wattage can be
"Low Efficacy"

Reference:
See 150.0(k)(3)
page 218

- Cabinet illumination must not exceed ≤ 20W / linear foot. Refer to code for calculation methods.

BATHROOMS

Sinks, toilets, shower and tub

High Efficacy Luminaires

At least one luminaire must be
"High Efficacy"

Low Efficacy Luminaires

Remaining luminaires can be
"Low Efficacy" controlled by a vacancy sensor

Reference:
See 150.0(k)(5)
page 218

LAUNDRY ROOMS AND UTILITY ROOMS

Attached laundry rooms and utility rooms

High Efficacy Luminaires

All must be "High Efficacy"
and controlled by a vacancy sensor

Low Efficacy Luminaires

None

Reference:
See 150.0(k)(6)
page 218

- Consider use of dual technology, IR and ultrasound, in large rooms such as garages where the potential of low motion can turn off the lighting

OTHER ROOMS

Hallways, dining rooms, family rooms, home offices, bedrooms, attic spaces, and closets

Exceptions: Closets <70 sf and detached buildings <1000sf

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy"
controlled by dimmers or vacancy sensors

Reference:
See 150.0(k)(7)
page 218

- Portable lighting must be T20 certified

OUTDOOR

Nonresidential compliance method can be used. For units with less than eight vehicles per site, residential compliance method is acceptable for multifamily: private patios, entrances, balconies, and porches.

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy" controlled by ON/OFF switch, motion sensor and one of the following photocontrol, astronomical time clock or EMCS

Reference:
See 150.0(k)(9)
page 219

- Offer two methods: 1. Can use "High Efficacy" or "low efficacy" with controlled by ON/OFF switch, motion sensor, and photocontrol/astronomical time clock/EMCS; 2. Can use nonresidential compliance methods.
- Parking lots with 8 or more vehicles must comply with nonresidential compliance. When less than 8 vehicles, the two methods mention above are allowed.

INTERIOR COMMON AREAS

Interior common areas with ≤20% of the floor of the floor area

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy" controlled by an occupancy sensor.

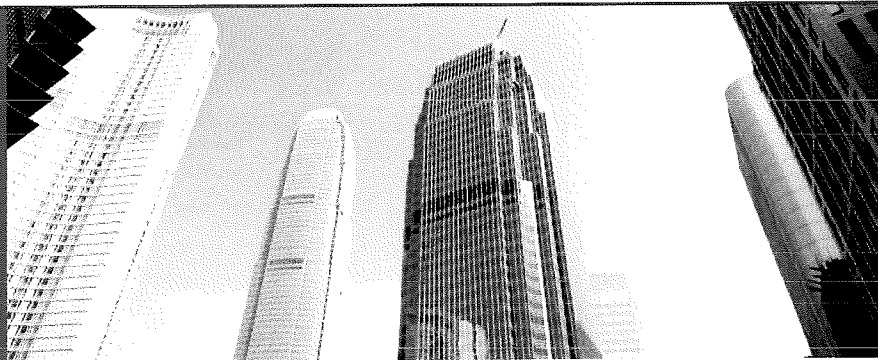
Reference:
See 150.0(k)(12)
page 219

- Total common areas with 20% or less floor area require "High Efficacy" or controlled by an occupancy sensor
- Areas 20% or greater require nonresidential compliance with paths of ingress and egress using occupancy sensors reducing power at least 50% when vacant

High-rise buildings, greater than 3 stories, are considered nonresidential except in each individual dwelling unit.

The interior spaces of these dwelling units and outdoor lighting switched from the inside of the unit are required to meet residential compliance requirements.

"High Efficacy" and "Low Efficacy" are to be separately switched with readily accessible manual ON/OFF control.



KITCHEN

Lighting circuits within the kitchen area are included

High Efficacy Luminaires

≥50% wattage must be
"High Efficacy"

Low Efficacy Luminaires

≤ 50% wattage can be
"Low Efficacy"

Reference:

See 150.0(k)(3)
page 218

- Cabinet illumination must not exceed ≤ 20W / linear foot. Refer to code for calculation methods.

BATHROOMS

Sinks, toilets, shower and tub

High Efficacy Luminaires

At least one luminaire must be
"High Efficacy"

Low Efficacy Luminaires

Remaining luminaires can be
"Low Efficacy" controlled by a vacancy sensor

Reference:

See 150.0(k)(5)
page 218

LAUNDRY ROOMS AND UTILITY ROOMS

Attached laundry rooms and utility rooms

High Efficacy Luminaires

All must be "High Efficacy"
and controlled by a vacancy sensor

Low Efficacy Luminaires

None

Reference:

See 150.0(k)(6)
page 218

- Consider use of dual technology, IR and ultrasound, in large rooms such as garages where the potential of low motion can turn off the lighting

OTHER ROOMS

Hallways, dining rooms, family rooms, home offices, bedrooms, attic spaces, and closets

Exceptions: Closets <70 square feet

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy"
controlled by dimmers or vacancy sensors

Reference:

See 150.0(k)(7)
page 218

- Portable lighting must be T20 certified

OUTDOOR

Private patios, entrances, balconies, and porches switched from inside the dwelling unit

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy" controlled by ON/OFF switch, motion sensor and one of the following photocontrol, astronomical time clock or EMCS

Reference:

See 150.0(k)(9)
page 219

- Optional types in area includes "High Efficacy" OR "Low Efficacy" using T20 photocell or T20 astronomical time clock or energy management control system (EMCS)
- For parking garage refer to nonresidential compliance

Dormitory facilities are generally considered nonresidential.

The dorm room is considered a dwelling and therefore the spaces found within the unit must comply with residential compliance requirements such as ICAT and "High Efficacy" luminaires.

"High Efficacy" and "Low Efficacy" are to be separately switched with readily accessible manual ON/OFF control.



KITCHEN

Lighting circuits within the kitchen area are included

High Efficacy Luminaires

≥50% wattage must be
"High Efficacy"

Low Efficacy Luminaires

≤ 50% wattage can be
"Low Efficacy"

Reference:

See 150.0(k)(3)
page 218

- Cabinet illumination must not exceed ≤ 20W / linear foot. Refer to code for calculation methods.

BATHROOMS

Sinks, toilets, shower and tub

High Efficacy Luminaires

At least one luminaire must be
"High Efficacy"

Low Efficacy Luminaires

Remaining luminaires can be
"Low Efficacy" controlled by a vacancy sensor

Reference:

See 150.0(k)(5)
page 218

LAUNDRY ROOMS AND UTILITY ROOMS

Attached laundry rooms and utility rooms to the dormitory room

High Efficacy Luminaires

All must be "High Efficacy"
and controlled by a vacancy sensor

Low Efficacy Luminaires

None

Reference:

See 150.0(k)(6)
page 218

- Consider use of dual technology, IR and ultrasound, in large rooms such as garages where the potential of low motion can turn off the lighting

OTHER ROOMS

Hallways, dining rooms, family rooms, home offices, bedrooms, attic spaces, and closets

Exceptions: Closets <70 square feet

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy"
controlled by dimmers or vacancy sensors

Reference:

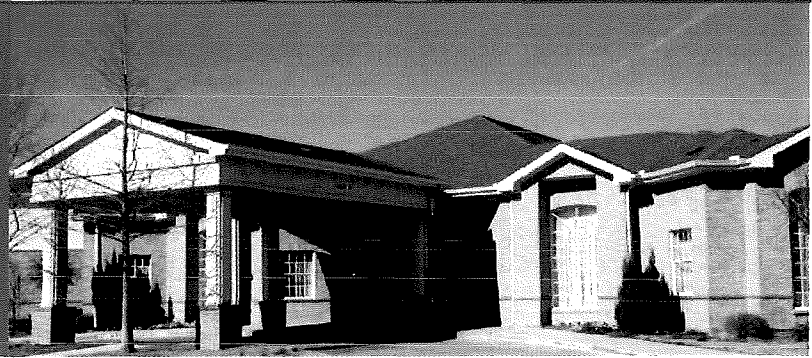
See 150.0(k)(7)
page 218

- Portable lighting must be T20 certified

Much like dormitory facilities, Senior Living facilities are generally considered nonresidential.

The living quarters for are considered dwelling spaces and also must comply with residential compliance requirement. Close review of these facilities should be made. If the spaces are utilized for hospital care, the space would no longer need to comply with residential requirements.

"High Efficacy" and "Low Efficacy" are to be separately switched with readily accessible manual ON/OFF control.



KITCHEN

Lighting circuits within the kitchen area are included

High Efficacy Luminaires

≥50% wattage must be "High Efficacy"

Low Efficacy Luminaires

≤ 50% wattage can be "Low Efficacy"

Reference:

See 150.0(k)(3) page 218

- Cabinet illumination must not exceed ≤ 20W / linear foot. Refer to code for calculation methods.

BATHROOMS

Sinks, toilets, shower and tub

High Efficacy Luminaires

At least one luminaire must be "High Efficacy"

Low Efficacy Luminaires

Remaining luminaires can be "Low Efficacy" controlled by a vacancy sensor

Reference:

See 150.0(k)(5) page 218

LAUNDRY ROOMS AND UTILITY ROOMS

Attached laundry rooms and utility rooms

High Efficacy Luminaires

All must be "High Efficacy" and controlled by a vacancy sensor

Low Efficacy Luminaires

None

Reference:

See 150.0(k)(6) page 218

- Consider use of dual technology, IR and ultrasound, in large rooms such as garages where the potential of low motion can turn off the lighting

OTHER ROOMS

Hallways, dining rooms, family rooms, home offices, bedrooms, attic spaces, and closets

Exceptions: Closets <70 sf and detached buildings <1000sf

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy" controlled by dimmers or vacancy sensors

Reference:

See 150.0(k)(7) page 218

- Portable lighting must be T20 certified

OUTDOOR

Private patios, entrances, balconies, and porches switched from inside the dwelling unit

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy" controlled by ON/OFF switch, motion sensor and one of the following photocontrol, astronomical time clock or EMCS

Reference:

See 150.0(k)(9) page 219

- Offer two methods: 1. Can use "High Efficacy" or "low efficacy" with controlled by ON/OFF switch, motion sensor, and photocontrol/astronomical time clock/EMCS; 2. Can use nonresidential compliance methods.
- For parking areas refer to nonresidential compliance

The guest rooms of Hotels and Motels are considered dwellings and fall under residential compliance requirements.

One High Efficacy luminaire switched separately within 6 feet of entry required.

Remaining lighting and controlled receptacles require captive card key, vacancy or occupancy sensing, or automatic control that allows them to remain on no longer than 30 min once the room is vacated. Ref: Section 130.1(c)

The remaining part of the building construction is classified as nonresidential.

"High Efficacy" and "Low Efficacy" are to be separately switched with readily accessible manual ON/OFF control.



KITCHEN

Lighting circuits within the kitchen area are included

High Efficacy Luminaires

≥50% wattage must be
"High Efficacy"

Low Efficacy Luminaires

≤ 50% wattage can be
"Low Efficacy"

Reference:

See 150.0(k)(3)
page 218

- Cabinet illumination must not exceed ≤ 20W / linear foot. Refer to code for calculation methods.

BATHROOMS

Sinks, toilets, shower and tub

High Efficacy Luminaires

At least one luminaire must be
"High Efficacy"

Low Efficacy Luminaires

Remaining luminaires can be
"Low Efficacy" controlled by a vacancy sensor

Reference:

See 150.0(k)(5)
page 218

LAUNDRY ROOMS AND UTILITY ROOMS

Attached laundry rooms and utility rooms

High Efficacy Luminaires

All must be "High Efficacy"
and controlled by a vacancy sensor

Low Efficacy Luminaires

None

Reference:

See 150.0(k)(6)
page 218

- Consider use of dual technology, IR and ultrasound, in large rooms such as garages where the potential of low motion can turn off the lighting

OTHER ROOMS

Hallways (inside the dwelling unit), dining and living rooms, home offices, bedrooms, storage spaces, and closets

Exceptions: Closets
<70 square feet

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy"
controlled by dimmers or vacancy sensors

Reference:

See 150.0(k)(7)
page 218

- Portable lighting must be T20 certified

OUTDOOR

Private patios, entrances, balconies, and porches switched from inside the dwelling unit

High Efficacy Luminaires

Can be "High Efficacy"

Low Efficacy Luminaires

Can be "Low Efficacy" controlled by ON/OFF switch, motion sensor and one of the following photocontrol, astronomical time clock or EMCS

Reference:

See 150.0(k)(9)
page 219

- Optional types in area includes "High Efficacy" OR "Low Efficacy" using T20 photocell or T20 astronomical time clock or energy management control system (EMCS)
- For parking areas refer to nonresidential compliance

RESIDENTIAL: Halo and Title 24 Residential Lighting Standards

Title 24 Overview of Residential Lighting Standards

HALO LED Recessed Lighting meets Title 24 requirements in all areas of the house when used with Halo LED recessed housings (non-screw base); for a complete high-efficacy luminaire.

HALO offers the largest selection of recessed LED certified to California Energy Commission Title 20 Appliance Efficiency Database. Luminaires listed on the Title 20 database are considered “high efficacy” products. Title 24 provides requirements for where high efficacy and low efficacy luminaires can be installed on a room-by-room basis. For specific LED listings refer to the CEC Title 20 Appliance Efficiency Database located at www.energy.ca.gov



Featured Halo High Efficacy Solutions listed on the Title 20 Database

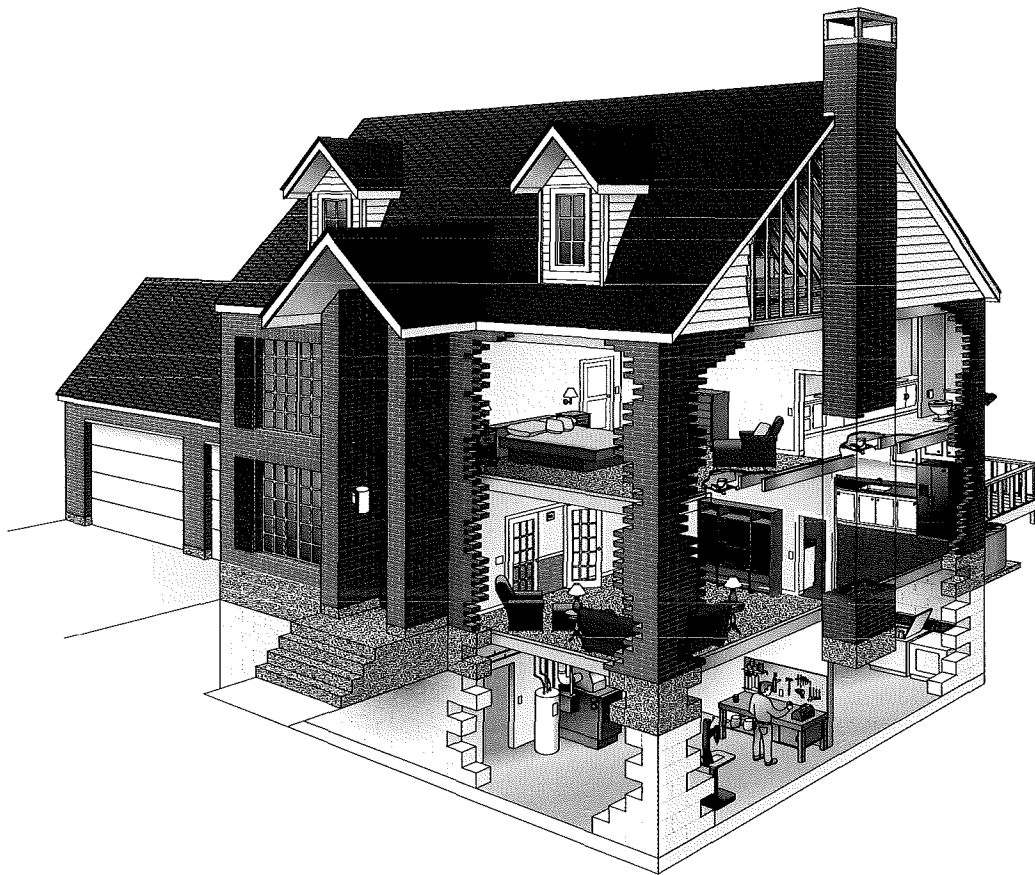


Title 24 Residential High Efficacy Lighting

- High efficacy luminaires may not have a medium screwbase socket.
- High efficacy luminaires must meet minimum lumen per watt and light source criteria per T24 & JA-8 California Code Standards
- LED residential luminaires must be certified to the CA Energy Commission (Title 20)
- Indoor LED nominal correlated color temperature (CCT) range of 2700K to 4000K (outdoor 2700K to 5000K)
- LED luminaire must be capable of providing a minimum 90 Color Rendering Index (CRI)
- Pin-base CFL luminaires $\geq 13W$
- Luminaires with GU-24 sockets rated for LED, CFL, or HID lamps are automatically qualified as high efficacy for residential use

High Efficacy Luminaire - LPW	
Luminaire Power Rating	Minimum Efficacy (Lumens per Watt)
5 watts or less	30
over 5 watts to 15 watts	45
over 15 watts to 40 watts	60
over 40 watts	90

RESIDENTIAL: Halo and Title 24 Residential Lighting Standards



Can be used for

T24

California Title 24
High Efficacy
Compliance

Kitchens*

Lighting in kitchen areas must have at least 50% of the total rated wattage as high efficacy. There is no limit on the total kitchen wattage or total illumination levels.

Kitchen Low Efficacy Trade-off Option

- When additional low efficacy lighting is needed (residential kitchen only)
- All kitchen lighting (low and high efficacy) must be controlled by vacancy sensors, dimmers, or lighting control system with vacancy and/or dimming function
- Refer to trade-off option wattage table

Kitchen Lighting Controls

Separate controls are required:

- High efficacy lighting
- Low efficacy lighting

Independent controls are recommended:

- Recessed lighting
- Undercabinet lighting
- Linear fluorescent lighting
- Uplights and task lighting

Bedrooms

Permanently installed lighting in bedrooms must be high efficacy or be controlled by a vacancy sensor or a dimmer

Bathrooms

Lighting in bathrooms must have (1) minimum high efficacy fixture. All other lighting shall be high efficacy or be controlled by a vacancy sensor

Laundry and Utility Rooms

Lighting fixtures in laundry and utility rooms must be high efficacy and be controlled by a vacancy sensor

Kitchen Undercabinet

Lighting mounted to a cabinet (not for inside cabinet lighting) shall be calculated as kitchen lighting where at least 50% of permanent lighting must be high efficacy. Lighting internal to cabinets shall use no more than 20W per linear foot of illumination cabinet.

Outdoor Lighting

Outdoor lighting attached to the building must be high efficacy or controlled by motion sensor and either a photocell or an astronomical time clock

Garages

Lighting in garages must be high efficacy and be controlled by a vacancy sensor.

Other Rooms**

Permanently installed lighting in "other rooms" must be high efficacy or be controlled by vacancy sensor or a dimmer

Residential Recessed Luminaires:

- UL Listed for IC, insulation contact
- Certified airtight label per ASTM E283 test standards
- Sealed gasket or caulk between luminaire and ceiling
- High efficacy luminaires must meet minimum lumens per watt and T-24 and JA-8 (per high efficacy definitions and LPW table)

Note: Title 24 requirements do not apply to portable floor lamps or table lamps.

Kitchen Low Efficacy Trade-off Option - Wattage	
Dwelling Size	Additional Low Efficacy Lighting
≤ 2,500 ft ²	up to 50W additional
> 2,500 ft ²	up to 100W additional

*Kitchens include dining areas when dining is on the same lighting circuit.

**Other rooms: hallways, closets, attics, home offices, dining, and family rooms.

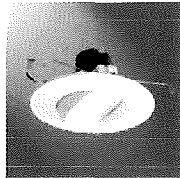
Vacancy sensor: Manual on/automatic off occupancy sensor. Must be certified by the manufacturer to the CA Energy Commission Title 20 Appliance Efficiency Regulations.

RESIDENTIAL: Product Reference Guide - High Efficacy Luminaires

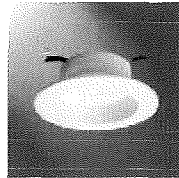
RECESSED DOWNLIGHT - HIGH EFFICACY TITLE 20 CERTIFIED (require dedicated LED ICAT housing)



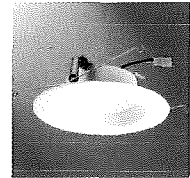
Halo
RA LED Series
4" Adjustable
RA4069_w/ICAT



Halo
RA LED Series
5" and 6" Adjustable
RA56069_w/ICAT



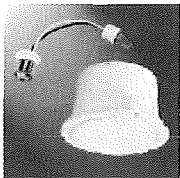
Halo
RL LED Series
4" Downlight
RL460_9_w/ICAT



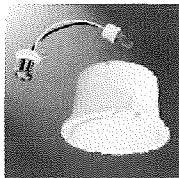
Halo
RL LED 600 Series
5" & 6" Downlight
RL560_69_w/ICAT



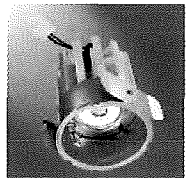
Halo
RL LED 900 Series
5" & 6" Downlight
RL56_99_w/ICAT



Halo
ML LED 600 Series
5" & 6" Downlight
ML56069_w/ICAT



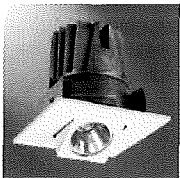
Halo
ML LED 900 Series
5" & 6" Downlight
ML56069_w/ICAT



Halo
EL LED Series
4" Downlight
EL4069_w/ICAT

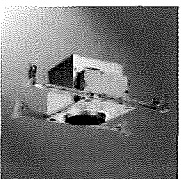


Halo
ELG Round LED Series
4" Adjustable
ELG4069_w/ICAT

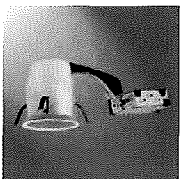


Halo
ELSG Square LED Series
4" Adjustable
ELGS4069_w/ICAT

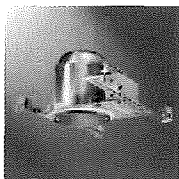
RECESSED HOUSINGS - ICAT - HIGH EFFICACY / NON-SCREW BASE



Halo
H4 LED Gen2 Housing
4" LED Housing
H457ICAT1E



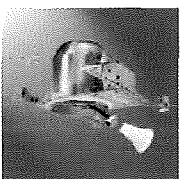
Halo
H4 LED Gen2 Housing
4" LED Remodel Housing
H457RICAT1E



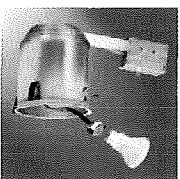
Halo
H750ICAT
6" LED Housing



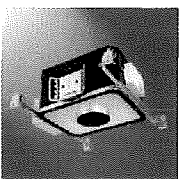
Halo
H750RICAT
6" LED Remodel Housing



Halo
H724ICATL
6" GU24 Housing
(lamp included)



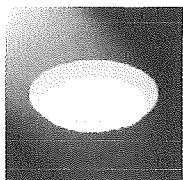
Halo
H724RICATL
6" GU24 Remodel Housing
(lamp included)



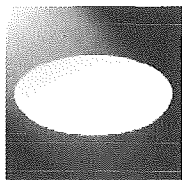
Iris
P3LED Series (90 CRI models)
3" Adjustable Housing
900 or 1200 Lumen options

RESIDENTIAL: Product Reference Guide - High Efficacy Luminaires

SURFACE AND RECESSED DOWNLIGHT - HIGH EFFICACY TITLE 20 CERTIFIED

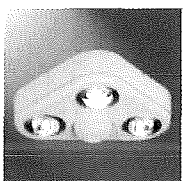


Halo
SLD4 LED Series 4"
SLD4069_



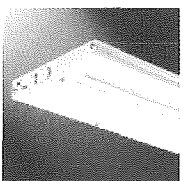
Halo
SLD6 LED Series 5" & 6"
SLD6069_

OUTDOOR



All Pro
Revolve Series
LED Outdoor Security

UNDERCABINET LIGHTING - HIGH EFFICACY TITLE 20 CERTIFIED

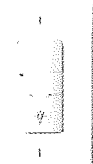


Halo
HU10 LED Series
18", 24", 34" and 48" Undercabinet
HU10_

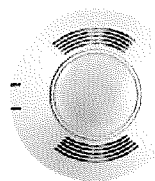
CONTROLS - TITLE 20 CERTIFIED



NeoSwitch
ONW
Recommended for bathrooms,
garages, laundry, utility and more



NeoSwitch
VNW
Recommended for bathrooms,
garages, laundry, utility and more



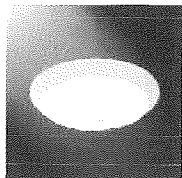
NeoSwitch
VAC
Recommended for "other
rooms" such as home offices



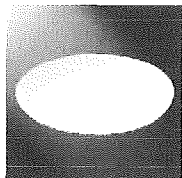
iLumen
Ineo CLS
Recommended for
kitchens, but not required

RESIDENTIAL: Product Reference Guide - Low Efficacy Luminaires

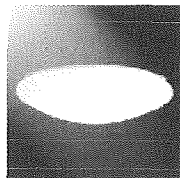
SURFACE & RECESSED DOWNLIGHT - LOW EFFICACY



Halo
SLD4 LED Series 4"
SLD4068_

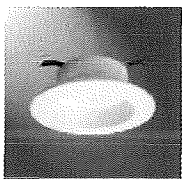


Halo
SLD6 LED Series 5" & 6"
SLD6068_

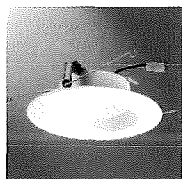


Metalux LED
FM Series Flushmounts, Ceiling or Wall
12", 16" and 20" White Rounds
FMLED_

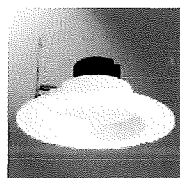
RECESSED DOWNLIGHT - LOW EFFICACY



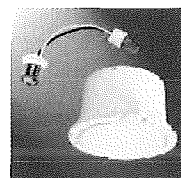
Halo
RL LED Series
4" Downlight
RL460_8_ w/ICAT



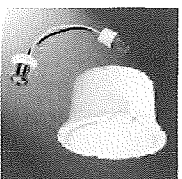
Halo
RL LED 600 Series
5" & 6" Downlight
RL560_68_ w/ICAT



Halo
RL LED 900 Series
5" & 6" Downlight
RL56_98_ w/ICAT

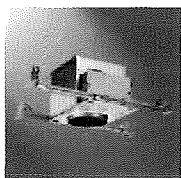


Halo
ML LED 600 Series
5" & 6" Downlight
ML56068_ w/ICAT

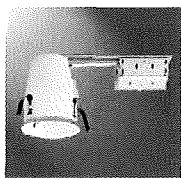


Halo
ML LED 900 Series
5" & 6" Downlight
ML56068_ w/ICAT

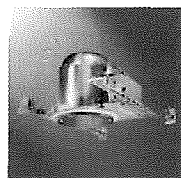
RECESSED HOUSINGS - LOW EFFICACY / SCREW BASE



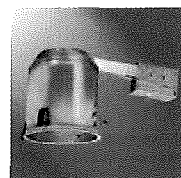
Halo
4" Incandescent Housing
H99ICAT



Halo
4" Incandescent
Remodel Housing
H99RTAT



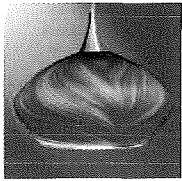
Halo
6" Incandescent Housing
H7ICAT



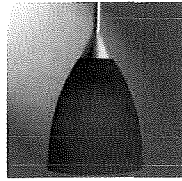
Halo
6" Incandescent
Remodel Housing
H7RICAT

RESIDENTIAL: Product Reference Guide - Low Efficacy Luminaires

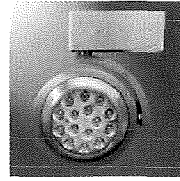
SPECIALTY - LOW EFFICACY



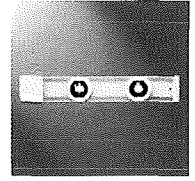
Halo Art Glass
Pendants



Halo
Soft Cone Pendant
SCN



HALO
High Output LED Track Fixture
806 / 807

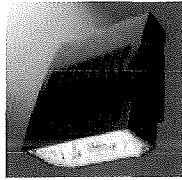


Halo
LED Undercabinet
HU20

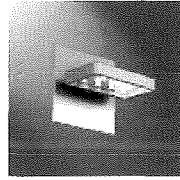
OUTDOOR - LOW EFFICACY



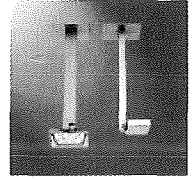
Lumark
Crosstour LED
Wall Pack
XTOR_



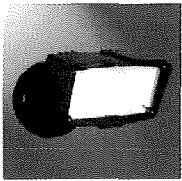
Lumark
Crosstour Maxx LED
Wall Pack
XTOR_



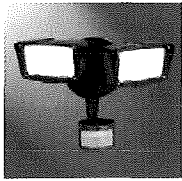
Lumiere
Eon Wall Series
LED Wall Mount
303W_



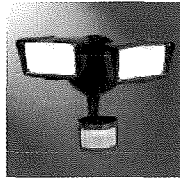
Lumiere
Eon Ceiling Series
LED Ceiling Light
303S1_



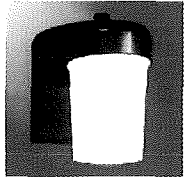
All-Pro
FSL2030L Series
LED Large Single Head
Floodlight



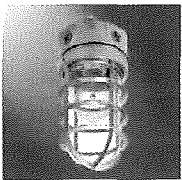
All-Pro
MST18920L Series
180° Motion Activated
Twin Head LED Floodlight



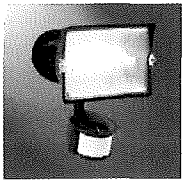
All-Pro
MST27920LES
270° Motion Activated
Twin Head LED Floodlight



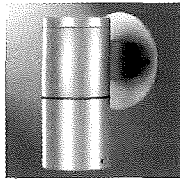
All-Pro
FE0650LPC Series
LED Entry and Patio light



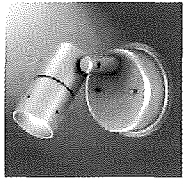
Consumer Products
VT100G
100 Watt Vapor Tight
Floodlight



Consumer Products
MS188 Series
180° 300 Watt Halogen
Security Floodlight












Lumiere
Westwood 714 Series
Wall Mount



Lumiere
Westwood 903 Series
Wall Mount

APPENDIX: Interior Lighting Control Application Quick Reference Guide

INTERIOR SPACES

	Minimum Required Control Type					Page Reference
	A	B	C	D	E	
	 Manually Switched ON/OFF	 Luminaire Dimming	     Vacancy Sensor, Occupancy Sensor, Automatic Time Switch, Countdown Timer or Remote Signal	 Daylighting Control	 Receptacle Control	
Office - Small	1	4, 6	≤250sf; 14	21, 24, 25, 27	26	14
Office - Medium or Large	1	4	>250sf; 7, 9, 12	21, 24, 25, 27	26	15
Corridor, Hall and Stairwell	1	4	9,15	21, 24, 25, 27		16
Conference Room	1	4	14	21, 24, 25, 27	26	17
Entry, Waiting and Lobby	1	4, 6	7, 9, 12	21, 24, 25, 27	26	18
Restaurant and Dining	1	4	7, 9, 12, 16	21, 24, 25, 27		19
Restroom - Single Stall	1	4, 6	4 or <70sf; 10	21, 24, 25, 27		20
Restroom - Multi-Stall	1, 2	4	4	21, 24, 25, 27		21
Parking Garage	1	4	17, 18	22, 23, 24, 25		22
Cafeteria, Multipurpose and Gym	1	4	Multipurpose Rooms <1,000sf; 14 Cafeteria and Gym <1,000sf; 7, 9, 12, 16	21, 24, 25, 27		23
Classroom	1	5	14	21, 24, 25, 27		24
Electrical or Mechanical Room	1	4	(<70sf; 10) or 4 or (Elect. Regulated by 110.23(D))	21, 24, 25, 27		25
Library Stacks	1	4	15	21, 24, 25, 27		26
Library Open Area	1	4	7, 9, 12	21, 24, 25, 27		27
Warehouse Racks	3	4	8, 13, 15, 16	21, 24, 25, 27		29
Loading Docks	3	4	8, 9, 13, 17, 18	21, 24, 25, 27		35
Server Aisle	1	4	7, 9, 11	21, 24, 25, 27		

ALTERATIONS AND MODIFICATIONS-IN-PLACE (see Section 141.0, and Tables 141.0-E and 141.0-F)

Luminaire Alterations (per space)				Reference: 141.0 (b)lii
<10% of Existing Luminaires	existing provisions permitted			
≥10% of Existing Luminaries				
≤85% Lighting Power per 140.6 Area Method	A	B	C	
>85% Lighting Power per 140.6 Area Method	A	B	C	Daylighting is required for luminaires “altered” >10,000sf
Luminaires Modified-in-Place				Reference: 141.0 (b)liii
<40 Luminaires /Year	existing provisions permitted			
≥40 Luminaires /Year				
Power ≤85%	A	B (one step between 30-70% and modified)	C	
Power >85%	A	B (multi-level for those modified)	C	D (for luminaires modified)

A,B,C,D: Controls required per column as shown in above INTERIOR Area Type Guide matrix. Refer to Controls Summary Table 130.1-A

APPENDIX: Interior Lighting Control Application Quick Reference Guide: Key and Support

INTERIOR REFERENCE KEY

1. MANDATORY: Luminaires must be manual switched ON/OFF for each area enclosed by ceiling-height partitions and independently controlled, readily accessible, and operated in the same room with the luminaires controlled. Ref: Section 130.1(a)
2. OPTION. May use manual switch not accessible to unauthorized personnel. Ref: Section 130.1(a)
3. MANDATORY. Switch shall be located so that the person using the lighting control can see the lights or area operated by the switch, or the area being lit is annunciated. Ref: Section 130.1(a)
4. MANDATORY. Enclosed spaces 100sf or greater with connected load greater than 0.5W/sf. Each luminaire must be controlled by one of five control methods; manual dimmer, lumen maintenance, tuning, daylighting, or demand response. Ref: Section 130.1(b), Table 130.1-A.
5. MANDATORY. General lighting load of 0.7W/sf or less requires one control step between 30-70%. Ref: Section 130.1(b)
6. EXCEPTION. Enclosed area with one luminaire having 2 or less lamps. LED luminaires are not part of the exception. Ref: Section 130.1(b)
7. MANDATORY. Each 5,000 sf or less enclosed area requires vacancy, occupancy, automatic time-switch, or signal controls capable of turning off the lighting when unoccupied. Ref: Section 130.1(c)
8. MANDATORY. Each 20,000 sf or less enclosed area requires vacancy, occupancy, automatic time-switch, or signal controls capable of turning off the lighting when unoccupied for these larger spaces. Ref: Section 130.1(c)
9. EXCEPTION. Lighting used for 24/7 operation. Ref: Section 130.1(c)
10. OPTION: Countdown timer allowed when less than 70sf with a 10 minute setting. Ref: Section 130.1(c)
11. OPTION: Countdown timer allowed with a 30 minute setting. Ref: Section 130.1(c)
12. MANDATORY: Automatic time-switch with a 2 hour setting. Automatic time-switch required to have a "holiday shut-OFF" feature to turn off all loads for at least 24hr, and then resume to normal schedule. Ref: Section 130.1(c)
13. OPTION: Countdown timer greater than a 2 hour setting allowed when automatic time-switch control used where captive-key override is utilized. Ref: Section 130.1(c)
14. MANDATORY. Vacancy or occupancy sensing control required to shut OFF ALL lighting when the room is unoccupied. This includes any classroom, any conference room, multipurpose rooms less than 1,000sf, and offices 250sf or less. Ref: Section 130.1(c)
15. MANDATORY. Partial ON/OFF vacancy or occupancy sensing control is required to reduce lighting power when unoccupied. Warehouse aisle ways and open warehouses shall reduce lighting power by at least 50%; Library book stacks 10 ft or longer accessible from one end and 20 ft or longer accessible from both ends shall reduce lighting power by 50% and done so in each library book stack aisle; General corridors and general stairwells shall reduce lighting power by at least 50% when each space is unoccupied and FULL ON at each designed path of egress; Common area corridors and common area stairwells providing access to dwelling units in buildings including high-rise, hotel/motel, and multi-family apartments shall reduce lighting power by at least 50% when each space is unoccupied and FULL ON at each designed path of egress. Ref: Section 130.1(c)
16. EXCEPTION: Installed lighting power is 80% or less of the allowed value for the areas and then at least 40% of the lighting power shall be reduced or when HID technology is deployed at least 40% of the lighting power shall be reduced. Ref: Section 130.1(c)
17. MANDATORY. Vacancy or occupancy sensing control shall have at least one control step between 20-50% of lighting power, no more than 500W controlled together as a single zone, and turn the lights FULLY ON in each controlled space activated from designed paths of egress. Areas include parking garages, parking areas, and loading/unloading docks. Ref: Section 130.1(c)
18. EXCEPTION. Metal halide luminaires with system efficacy of 75lpw shall have at least one control step between 20-60% of lighting power. Ref: Section 130.1(c)
19. MANDATORY. Hotel/motel guest rooms require captive card key, vacancy or occupancy sensing, or automatic control that allows the lighting power and controlled receptacles to remain on no longer than 30 min once the room is vacated. Ref: Section 130.1(c)
20. EXCEPTION. One "High Efficacy" luminaire located within 6 feet of entry door. Ref: Section 130.1(c)
21. MANDATORY. The indoor, non-parking garage daylighting zones shall be controlled separately. These zones are Skylit, Primary Sidelit, and Secondary Sidelit. Sidelit zones apply when a space has at least 24 sf of glazing. Luminaires that fall in both Skylit and Primary Sidelit are to be controlled as part of the Skylit zone. Luminaires that are at least 50% within the zone are considered part of the designated zone. The luminaires in the daylighting zones must meet the multilevel lighting and uniformity requirements. Illuminance of daylight controlled lighting shall not be less than the space not controlled. When illuminance exceeds 150% of the designed illuminance, the general lighting in the daylighting zones shall be reduced by a minimum of 65%. Ref: Section 130.1(d) and Table 130.1-A
22. MANDATORY. The parking garage daylighting zones shall be controlled separately. These zones are Primary Sidelit, and Secondary Sidelit. Sidelit zones apply when a space has at least 36 sf of glazing and when the Primary Skylit zone has lighting loads greater than 60W. Luminaires that are at least 50% within the zone are considered part of the designated zone. The luminaires in the daylighting zones must meet the multilevel lighting and uniformity requirements OR ON/OFF. Illuminance of daylight controlled lighting shall not be less than the space not controlled. When illuminance exceeds 150% of the designed illuminance, the general lighting in the daylighting zones shall be reduced to zero. Ref: Section 130.1(d) and Table 130.1-A
23. EXCEPTION. Luminaires located in the daylight transition zone and for only dedicated ramps do not require daylight control. Ref: Section 130.1(d)
24. MANDATORY. Photosensors and their calibration adjustment shall be only accessible to authorized personnel. Ref: Section 130.1(d)
25. EXCEPTION. Daylit controlled lighting having a lighting power density of less than 0.3W/sf do not require multilevel lighting control. ON/OFF control is sufficient. Ref: Section 130.1(d)
26. MANDATORY. 120V receptacle control required for each within each 6 ft of uncontrolled receptacles and the controlled receptacle shall be marked. Hotel/motel guest rooms require that ½ of the receptacles to be controlled. Ref: Section 130.5(d)
27. EXCEPTION. When the combined total wattage of Skylit and Primary Sidelit zones is less than 120W, daylighting is not required.

APPENDIX: Multi-Level Requirements Quick Reference Guide

MULTI-LEVEL LIGHTING CONTROLS AND UNIFORMITY REQUIREMENTS (Summary of Table 130.1-A)







Luminaire Type	Minimum Required Control Steps (percent of full rated power ¹)				Uniform level of illuminance shall be achieved by:
Line-voltage sockets except GU-24	Continuous dimming 10-100 percent				
Low-voltage incandescent systems					
LED luminaires and LED source systems					
GU-24 rated for LED					
GU-24 sockets rated for fluorescent > 20 watts	Continuous dimming 20-100 percent				
Pin-based compact fluorescent > 20 watts ²					
GU-24 sockets rated for fluorescent ≤ 20 watts	Minimum one step between 30-70 percent				Stepped dimming; or Continuous dimming; or Switching alternate lamps in a luminaire
Pin-based compact fluorescent ≤ 20 watts ²					
Linear fluorescent and U-bent fluorescent ≤ 13 watts					
Linear fluorescent and U-bent fluorescent > 13 watts	Minimum one step in each range:				Stepped dimming; or Continuous dimming; or switching alternate lamps in each luminaire, having a minimum of 4 lamps per luminaire, illuminating the same area and in the same manner
	20-40 %	50-70 %	80-85 %	100 %	
Track Lighting	Minimum one step between 30 – 70 percent				Step dimming; or Continuous dimming; or Separately switching circuits in multi- circuit track with a minimum of two circuits.
HID > 20 watts	Minimum one step between 50 - 70 percent				Stepped dimming; or Continuous dimming; or Switching alternate lamps in each luminaire, having a minimum of 2 lamps per luminaire, illuminating the same area and in the same manner.

1. Full rated input power of ballast and lamp, corresponding to maximum ballast factor

2. Includes only pin based lamps: twin tube, multiple twin tube, and spiral lamps

APPENDIX: Exterior Lighting Control Application Quick Reference Guide

EXTERIOR SPACES

	 BUG / Zonal Lumen Control	 1500W Controlled Together	 Photocontrol or Astronomical Time-Switch	 Occupancy Sensor	 Multi-Level Dimming	 Part-Night Control
Incandescent Luminaires	B	F	D	A		
Public Right of Way (roadways, sidewalks, bikeways)	C		E			
Roadway Tunnels	C		E			
Building Facades	C, N		D	L, N or	G	K, M or
Ornamental Hardscapes	B, N		D	L, N or	G	K, M or
Outdoor Dining	B, N		D	L, N or	G	K, M or
Outdoor Sales (Frontage, Lots, and Canopies)	B		D	L, N or	G	K or M
General Parking Lots (Hardscapes pole mounted >24ft)	B		D			
General Parking Lots (Hardscapes pole mounted <= 24ft)	B	F	D	F, H	G, H, J	
General Wall Mounted (non-pole mounted >24ft)	B		D			
General Wall Mounted (non-pole mounted <=24ft)	B	F	D	F, I	G, I, J	

EXTERIOR ALTERATIONS

Increases in Lighting Load, All Luminaires must meet the requirements; More than 50% of Luminaires Replaced, All Luminaires must meet the requirements; 10% or More of the Luminaires Replaced, the Altered Luminaires must meet the requirements.

Incandescent Luminaires	B	F	D	A		
Public Right of Way (roadways, sidewalks, bikeways)	C		E			
Roadway Tunnels	C		E			
Building Facades	C, N		D	L, N	G	K, M
Ornamental Hardscapes	B, O, N		D	L, N	G	K, M
Outdoor Dining	B		D	L, N	G	K, M
Outdoor Sales (Frontage, Lots, and Canopies)	B, O		D	L	G	K
General Parking Lots (Hardscapes pole mounted >24ft)	B, O		D			
General Parking Lots (Hardscapes pole mounted <= 24ft)	B, O	F	D	F, H, J	G, H, J	
General Wall Mounted (non-pole mounted >24ft)	B		D			
General Wall Mounted (non-pole mounted <=24ft)	B	F	D	F, I, J	G, I, J	

EXTERIOR REFERENCE KEY

- A. MANDATORY. Incandescent luminaire rated over 100W must be controlled by a motion sensor to turn-on when occupied. Ref: Section 130.2(a)
- B. MANDATORY. Luminaire must meet the cutoff requirements when the lamp wattage is greater than 150W complying with BUG requirements in accordance with the appropriate lighting zone. Ref: Section 130.2(b), Table 130.2-A, Table 130.2-B
- C. EXCEPTION. Lighting is not required to meet the cutoff requirements for building facades, public monuments, vertical surfaces of bridges, health or life-safety regulations, public right of way for publicly maintained areas (roadways, sidewalks, bikeways) and temporary lighting. Also replacement of existing pole mounted luminaires in hardscape areas with all the following conditions: existing luminaires do not meet BUG rating, spacing between existing poles is greater than 6 times mounting height of the existing luminaires, new wiring is not being installed, and connected load is not increased. Ref: Section 130.2(b)
- D. MANDATORY. Outdoor controls shall be controlled by a photosensor OR outdoor astronomical time-switch that turns OFF the outdoor lighting when daylight is available. The outdoor lighting must be circuited and independently controlled from other electrical loads. Ref: Section 130.2(c)
- E. EXCEPTION. Controls are not required to turn OFF outdoor lighting for health or life-safety regulations applications and in tunnels illuminated 24/7. Ref: Section 130.2(c)
- F. MANDATORY. Luminaires installed 24 feet or less above the ground shall be controlled. No more than 1500W can be controlled together. Motion or other controls shall automatically reduce the power of each luminaire when vacant and turn to full-ON when area becomes occupied. Ref: Section 130.2(c)
- G. MANDATORY. When controlled, the luminaires must reduce power between 40-80% which allows for both stepped and continuous dimming. Ref: Section 130.2(c)
- H. EXCEPTION. Pole mounted luminaires 75W or less do not require controls that automatically reduce power when vacant. Ref: Section 130.2(c)
- I. EXCEPTION. Non-pole mounted luminaires 30W or less do not require controls that automatically reduce power when vacant. Ref: Section 130.2(c)
- J. EXCEPTION. Linear lighting 4W per linear foot or less do not require controls that automatically reduce power when vacant. Ref: Section 130.2(c)
- K. MANDATORY. Part-night outdoor lighting control. Ref: Section 130.2(c)
- L. MANDATORY. Motion sensors of automatically reducing lighting power with auto-ON functionality. Ref: Section 130.2(c)
- M. MANDATORY. Centralized time-based zone lighting automatically reducing lighting by a minimum of 50%. Ref: Section 130.2(c)
- N. MANDATORY. Wall mounted luminaires ("wallpacks") must provide a bilaterally symmetric distribution. Ref: Section 130.2(c) 5 D
- O. Replacement of existing pole mounted luminaires do not need to meet the requirements whereby spacing is greater than 6x mounting height of existing luminaires, no poles added, no new wiring and connected power is not increasing.

Lighting Power Density Tables

BUILDING METHOD REQUIREMENTS: LIGHTING ENERGY BUDGET

TYPE OF BUILDING	LPD
	ALLOWED LIGHTING POWER DENSITY (WATTS PER SQUARE FOOT)
Auditorium Building	1.5
Classroom Building	1.1
Commercial and Industrial Storage Building	0.6
Convention Center Building	1.2
Financial Institution Building	1.1
General Commercial Building/Industrial Work Building	1.0
Grocery Store Building	1.5
Library Building	1.3
Medical Building/Clinic Building	1.1
Office Building	0.8
Parking Garage Building	0.2
Religious Facility Building	1.6
Restaurant Building	1.2
School Building	1.0
Theater Building	1.3
All others buildings	0.6
Refer to specific application page for Area Method	

Reference:

Table 140.6-B for additional details page 190

OUTDOOR LUMINAIRES: LIGHTING ENERGY BUDGET

Lighting Zones:	LPD Lighting Power Density			
	Zone 1	Zone 2	Zone 3	Zone 4
Area Wattage Allowance (AWA) [watts per square foot]	0.035	0.045	0.090	0.115
Linear Wattage Allowance (LWA) [watts per linear foot]	0.25	0.45	0.60	0.85
Initial Wattage Allowance (IWA) [wattage]	340	510	770	1,030

*Additions can be added to the total budget where they apply.

Reference:

Table 140.7-A pages 195-197 for additional power allowances by specific applications.*

Notes

Notes

**Our Lighting
Product Lines**

Halo
Halo Commercial
Portfolio
Iris
RSA
Metalux
Corelite
Neo-Ray
Fail-Safe
MWS
Ametrix
Shaper
io
Lumark
McGraw-Edison
Invue
Lumière
Streetworks
AtLite
Sure-Lites

**Our Controls
Product Lines**

Greengate
iLumin
Zero 88
Fifth Light Technology
iLight (International Only)



Eaton
1121 Highway 74 South
Peachtree City, GA 30269
P: 770-486-4800
www.eaton.com/lighting

Canada Sales
5925 McLaughlin Road
Mississauga, Ontario L5R 1B8
P: 905-501-3000
F: 905-501-3172

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Food safety and environmental quality impose conflicting demands on Central Coast growers

by Melanie Beretti and Diana Stuart

Growers of fresh produce on the Central Coast of California currently face conflicting demands regarding measures to protect food safety and those to protect environmental quality. To explore the extent of conflicting pressures and identify the range of possible impacts on the environment, we conducted a survey of Central Coast irrigated-row-crop growers during spring 2007. The results indicate that growers are experiencing a clear conflict, and some are incurring economic hardships because their practices to protect the environment have resulted in the rejection of crops by buyers. In addition, some growers are being encouraged to or are actively removing conservation practices for water quality, and most growers are taking action to discourage or eliminate wildlife from and adjacent to croplands. These actions could affect large areas of land on the Central Coast and, as indicated by growers, they are likely to increase over time.

The Central Coast of California supports unique biodiversity and some of the most productive agricultural lands in the United States. The Salinas Valley in Monterey County, often referred to as the “Salad Bowl of America,” produces the majority of the nation’s lettuce. Since the 1990s, food safety has become increasingly important, especially with respect to outbreaks of *E. coli* O157:H7 associated with leafy greens: lettuce, escarole, endive, spring mix, spinach, cabbage, kale, arugula and chard (see www.caleafygreens.ca.gov).

Simultaneously, growers on the Central Coast face increasing demands to



Growers of leafy greens and vegetables must balance the need to improve water quality and wildlife habitat in and around farms, with concerns about food safety.

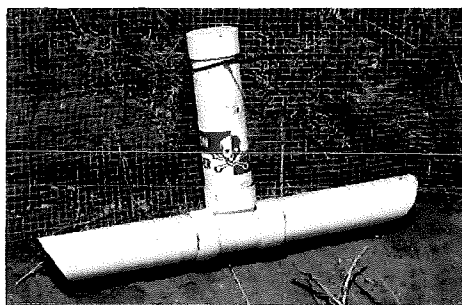
protect the environment and have taken a proactive approach to improve environmental quality. An important aspect of these efforts is the adoption of conservation practices, which aim to improve and protect water quality, prevent soil erosion, reduce the use of agricultural chemicals and protect wildlife. However, some food safety requirements — or field-level interpretations of these requirements — conflict with management practices intended to improve water quality and enhance natural habitat.

In response to grower concerns over contradictory guidelines and requirements for food safety and environmental protection, the Resource Conservation District (RCD) of Monterey County conducted a mail survey of 600 irrigated-row-crop growers throughout the Central Coast. The purpose was to better understand the impacts of conflicting demands on growers, and to provide information to aid attempts to reconcile the goals of food safety and environmental protection.

Protecting environmental quality

The Central Coast contains some of the greatest biodiversity of any temperate region in the world. At its heart is the Monterey Bay National Marine Sanctuary, the largest marine sanctuary in the United States, and the Elkhorn Slough National Estuarine Research Reserve.

While the Central Coast houses many natural resources, according to the Central Coast Regional Water Quality Control Board (CCRWQCB), it also has some of the most polluted waters in California. The Pajaro River and Elkhorn Slough are listed as impaired for sediment and nutrients under California’s 2002 Section 303(d) of the 1972 Clean Water Act. The Salinas River is 303(d)-listed as impaired for sediment, nutrients, pesticides and pathogens. In 2003, the 20-year-old state Agricultural Waiver of Nonpoint Source Discharge ended, meaning that growers are no longer exempt from water qual-



Mule deer/U.S. Department of the Interior

ity laws. In response, the CCRWQCB adopted a Conditional Waiver Program in 2005, which requires growers to enroll in the program, attend water-quality training sessions, adopt farm water-quality management plans, complete management practice checklists and participate in water quality monitoring (Cal EPA 2007).

An important aspect of these efforts is the adoption of conservation practices, which aim to improve and protect water quality, prevent soil erosion, reduce the use of agricultural chemicals and protect wildlife. Vegetation on and around farmland is a key component, including vegetated field borders, grassed waterways, riparian buffers and constructed wetlands. For the past decade, the Central Coast farming community has been proactively working with resource agencies to develop and implement voluntary conservation practices to improve water quality and reduce water consumption through the adoption and implementation of the Monterey Bay National Marine Sanctuary's Agricultural and Rural Lands Plan (MBNMS 1999). Adoption of these practices has now become a key component for compliance with the CCRWQCB's Conditional Waiver Program.

Protecting food safety

Since the late 1990s, government agencies, researchers and the produce industry have worked to develop and implement voluntary guidelines, or Good Agricultural Practices, to minimize the risk of food contamination (FDA 1998; Bihn 2004). These practices aim to protect consumer health at all levels of leafy greens production and distribution, and they have become increasingly important in light of recent outbreaks. The September 2006 outbreak of *E. coli* O157:H7 associated with bagged spinach from the Central Coast resulted in the loss of three lives and caused more than 200 illnesses.

This outbreak affected consumers in 26 states, drawing national attention (CDC 2006) and acting as a catalyst for rapid change in food safety protection efforts for leafy greens. Despite an intensive investigation, the U.S. Food and Drug Administration (FDA) and the California Department of Health Services (CDHS) have not been able to conclusively determine the specific causes of the spinach outbreak (CDHS/FDA 2007).

In early 2007, with oversight by the California Department of Food and Agriculture (CDFA), produce industry representatives developed the California Leafy Green Products Handler Marketing Agreement (see www.caleafygreens.ca.gov). More than 100 handlers (companies that move fresh produce products from growers to retail and food-service buyers) are signatories. Representing more than 99% of the leafy greens production in California, they are obligated to handle leafy green produce only from growers who adhere to the best management practices detailed in the Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, known as the "Metrics" (see www.caleafygreens.ca.gov). The Metrics were developed and continue to be updated through a process involving the produce industry, government agencies, natural resource organizations and scientists.

In addition to the Metrics, many companies and retailers who handle or sell leafy greens have developed their own company-specific food safety requirements, which also affect farm management practices. Because growers often sell their crops to multiple buyers, most now must meet at least one if not several different sets of requirements. In addition, field interpretations of the Metrics and company-specific guidelines vary. Depending on the size and type of operation, a grower may conduct self-audits

Left, a poison bait trap and fence to keep small animals out of fields; center, a small mammal/amphibian exclusion fence constructed around a tail-water recovery pond; right, mule deer. In the survey, a Central Coast grower could not sell \$17,500 worth of crops because a food safety audit found deer tracks near the field.

as well as undergo food safety inspections and audits by the CDFA, processors, grower-shippers or third-party auditors representing the companies that purchase their products.

Specific measures stated or implied in the Metrics and company-specific requirements may potentially conflict with efforts to improve and protect water quality and support wildlife habitat. For example, the Metrics identify "animals of significant risk" for contaminating crops and provide remediation guidelines. Measures to deter animals and comply with food safety requirements, such as fencing and bare-ground buffers around fields, can also result in adverse impacts to the environment. This may include the alteration or elimination of wildlife habitat, including the removal of surrounding vegetation. Noncrop vegetation is a key component of conservation practices such as field borders, grassed waterways and riparian buffers. Because vegetation provides water filtration and absorption, and reduces the deposition of sediment and pollutants into waterways, widespread vegetation removal could have significant environmental impacts.

Mail survey to row-crop growers

The Monterey County RCD conducted a mail survey in spring 2007, which was co-sponsored by the Grower-Shipper Association of Central California, the Central Coast Agriculture Water Quality Coalition and the Monterey County Agricultural Commissioner's office. The survey packet and cover letter were mailed to

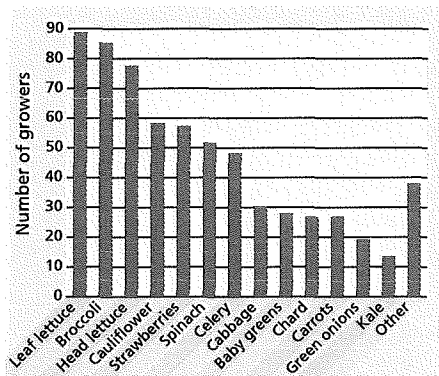


Fig. 1. Number of respondents who grow each commodity; most grow more than one crop.

TABLE 1: Responding growers who have adopted specific conservation practices (n = 181; most growers adopted more than one)

Conservation practice	Respondents
	%
Cover crop	72.1
Stormwater pond	38.5
Filter strip	36.3
Grassed waterway	33.5
Irrigation reservoir	30.2
Tailwater recovery pond	29.6
Hedgerow	25.7
Riparian restoration	18.4
Constructed wetland	6.1
Other	3.9

all 600 row-crop operations listed on the CCRWQCB Conditional Waiver Program's mailing list. These growers had operations in Monterey, San Benito, Santa Barbara, Santa Clara, Santa Cruz and/or San Luis Obispo counties. Three weeks following the initial mailing, a reminder postcard was sent to the entire mailing list.

The four-page survey contained 39 questions, consisting of multiple choice, yes/no, five-point Likert-scale and open-ended questions. Questions included details on farm operations, participation in conservation programs, the adoption of conservation practices, specifics about food safety requirements, information on how respondents are changing or have changed their practices, and opinion-oriented questions to allow respondents to make comments and voice concerns.

The survey also asked respondents about the circumstances under which they have had crops rejected by buyers and auditors due to food safety concerns as well as the economic impacts of these

rejections. Growers were asked a series of questions related to food safety, and practices to protect water quality and the environment. The survey sought responses on three main categories of practices and/or natural features: (1) noncrop vegetation, (2) ponds or waterways and (3) wildlife.

Analysis of the results included descriptive statistics as well as the comparison of data between different groups of respondents. We looked at differences between respondents who indicated that they grow leafy greens and those who grow other crops. In addition, we explored how other characteristics such as operation size and type (conventional or organic) affect management decisions. We used the Pearson Chi Square statistic to test for significance.

Food safety vs. water quality

A total of 181 growers returned surveys, for a 30% response rate. Almost all respondents indicated that they grow more than one crop, primarily leaf lettuce, broccoli, head lettuce, cauliflower, strawberries, spinach, celery, cabbage and baby greens (fig. 1). Approximately 86% grow conventional only or both conventional and organic, whereas 13% were organic only.

More than 80% of the respondents met education requirements of the Conditional Waiver Program through attendance at the Farm Water Quality Planning Short Course and had completed Farm Water Quality Plans. Ninety-one percent (91.1%) had adopted one or more conservation practices

TABLE 2: Survey responses (n = 181) regarding experiences with food safety audits, concerning the presence of noncrop vegetation, ponds/waterbodies and wildlife

Question	Affirmative responses
	%
"It has been suggested that I should remove noncrop vegetation"	18.6
"I have lost points on audit reports because of noncrop vegetation"	9.6
"It has been suggested that I should remove ponds or waterbodies"	9.5
"I have lost points on audit reports because of ponds or waterbodies"	10.8
"It has been suggested that I should remove wildlife"	39.0
"I have lost points on audit reports because of wildlife"	13.0

aimed to improve water quality and/or wildlife habitat. Sixty-three percent (62.8%) had received technical assistance for water quality or habitat improvement projects from a local resource agency or expert such as the RCD or USDA Natural Resources Conservation Service. Cover cropping was the most common practice adopted by respondents (72.1%) (table 1).

Crop rejection. Eight percent (8.0%) of growers reported that their crops had been rejected based on the presence of practices to improve water quality or wildlife habitat on the farm. Some of the explanations shared by respondents included:

- Lost \$17,500 worth of crop due to deer tracks.
- 1 acre of romaine lettuce rejected due to proximity to horse pen.
- 23 acres of head lettuce and 2 acres of mixed lettuce rejected due to contact with Salinas River floodwater.
- Crop rejected due to potential frog habitat.
- Portions of fields rejected by processor if frogs, tadpoles, snails, mice or other small animals were found.
- Harvest stopped due to the presence of frogs and tadpoles in creek.
- Crop rejected due to deer intrusion.
- Crops planted for processor near trees needed a buffer of 100 to 150 feet.

In some cases crops were not rejected outright; however, growers responded that their buyers, auditors or others had suggested either discouraging or eliminating noncrop vegetation, water bodies and wildlife in and around fields. Growers reported they had lost points on food safety audits due to the presence of noncrop vegetation (9.6% of respondents), water bodies (10.8%) and wildlife (13%) near their crops (table 2). Growers also indicated that in some cases they acted in response to buyer/auditor suggestions and actively removed these features or adopted mitigation measures accepted by their auditors or buyers. In all three categories (noncrop vegetation, water bodies and wildlife), growers of leafy greens were more likely to have been told to discourage or eliminate these features than growers of other crops. In two of the three categories (noncrop vegetation and wildlife) leafy greens growers were

TABLE 3: Comparison of affirmative responses by leafy green versus nonleafy green growers (n = 181) to questions concerning the removal of conservation practices or natural features in or adjacent to cropland

Question	Growers of	
	Leafy greens	Nonleafy greens
 %	
"It has been suggested that I should remove noncrop vegetation"	32.1*	2.8
"I have actively removed noncrop vegetation in response to comments by auditors or others"	32.1*	6.9
"It has been suggested that I should remove ponds or water bodies"	14.8*	3.0
"I have actively removed ponds or water bodies in response to comments by auditors or others"	7.4	6.0
"It has been suggested that I should remove wildlife"	47.7†	27.9
"I have actively removed wildlife in response to comments by auditors or others"	40.7*	23.5

* $P < 0.05$.

† $P < 0.10$.

significantly ($P < 0.05$) more likely than growers of other crops to have acted on these suggestions (table 3).

Conservation practice abandonment. Approximately 15% of all growers surveyed indicated that they had removed or discontinued the use of previously adopted conservation practices in response to suggestions made by auditors or buyers due to food safety concerns. Growers of leafy greens were significantly ($P < 0.05$) more likely to have taken out conservation practices than other growers: 21.1% indicated that they had actively taken out one or more conservation practices due to food safety concerns, as compared to 7.4% that grow nonleafy green crops.

Practices that had been removed or were planned for removal included: (1) ponds and/or reservoirs (such as irrigation reservoirs, duck habitat and ponds); (2) irrigation reuse systems (such as tail-water recovery ponds and water reuse); and (3) noncrop vegetation (such as grassed waterways, filter/buffer strips and trees/shrubs). In addition, some growers stated that although they had not yet removed conservation practices, they were planning to or felt they

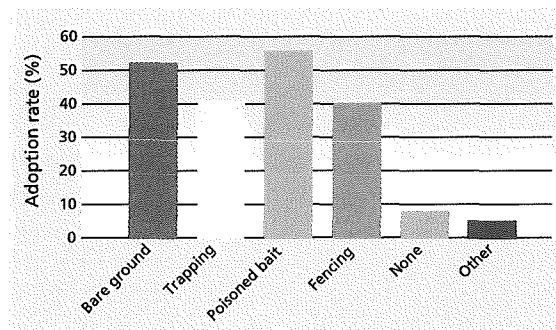


Fig. 2. Percentage of respondents who indicated they have adopted specific mitigation measures for wildlife.

would be required to in the near future. Several respondents suggested that a follow-up survey would reveal more changes being made.

Wildlife exclusion. Some 88.9% of the survey respondents indicated that they had adopted at least one measure to actively discourage or eliminate wildlife from cropped areas (fig. 2). The most commonly adopted measures were: bare-ground buffers, fencing, trapping and poisoned bait stations. Bare-ground buffers and poisoned bait stations were each used by more than half of the respondents to protect crops from wildlife intrusion. Trapping and fencing were each used by approximately 40%. Growers of leafy greens were significantly more likely to be using bare-ground buffers ($P < 0.05$), poisoned bait stations ($P < 0.05$) and traps ($P < 0.01$).

Growers most affected. Results from the survey suggest that the conflict between food safety and environmental protection disproportionately affects respondents who sell to shippers and packers, operate on more than 500 acres and grow conventionally (as opposed to organic only). Of respondents who had removed conservation practices, 87.8% sell to shippers and packers, whereas only 67% of all respondents sold to shippers and packers. Of respondents who had removed conservation practices 89% operate more than 500 harvested acres, whereas only 39% of all respondents operated more than 500 harvested acres.

In addition, large farm operators (> 500 acres) were significantly ($P < 0.05$) more likely to have been told to eliminate wildlife and waterways and significantly more likely to have adopted mitigation measures. Of the respondents who had removed conservation practices, 100% grew conventionally (conventional, and conventional and organic

operations), whereas 86% of all respondents grew conventionally.

Acreage affected. The growers who responded to the survey manage more than 140,000 acres of row-crop land on the Central Coast. Of these, those who had actively removed conservation practices for water quality or wildlife habitat (in response to suggestions by food safety auditors or others) manage nearly 30,000 acres. In addition, respondents who had adopted measures to actively deter or eliminate wildlife manage more than 133,000 acres. Survey respondents that use bare-ground buffers manage 91,890 acres (65% of the total land reported); trapping manage 87,279 acres (62%); poisoned bait stations manage 108,283 acres (77%); and fencing manage 66,380 acres (47%).

Grower comments. More than 30% of all respondents also chose to share their personal opinions and concerns at the end of the survey. These comments indicated that many growers face serious pressure regarding food safety, and they are concerned about doing things that may have negative impacts on the environment. Their responses suggested that in many cases growers have little choice in their management practices and must be responsive to buyers' and auditors' suggestions in order to sell their crops. For example, one grower wrote: "I am afraid many positive environmental programs and practices are going to be abandoned due to retailers'/shippers' new food safety practices. I am all for the environment and safe food, but feel many new food safety ideas are being driven by fear and uncertainty rather than sound science."

And another wrote: "Our experience has been that the food safety auditors have been very strict about any vegetation that might provide habitat. We are very concerned about upsetting the

natural balance, but we have to comply with our shipper's requests."

Conflict on the Central Coast

The survey results illustrate that growers are in the middle of a clear conflict between current food safety standards and continued efforts to address water quality and environmental concerns on the Central Coast. It appears that growers of leafy greens who operate larger acreages are especially affected by food safety concerns; however, other growers are also affected to a lesser extent. Growers are incurring economic hardships due to the rejection of crops based on the presence of practices to protect the environment. Some growers are encouraged to or are actively removing conservation practices in response to food safety audits and concerns. Many growers are taking action to discourage or eliminate wildlife and

habitat, natural lands, hedgerows and windbreaks. Discouraging or actively removing these features will have negative environmental impacts and, in some cases, could actually *increase* the risk of crop contamination (Stuart 2006; Stuart et al. 2006).

For example, contamination in overland water flows may be reduced by filtration through perennial forage or grasses (Tate et al. 2006). Vegetated treatment systems (such as grassed waterways and vegetated basins) have also been shown to reduce the presence and transport of pathogens (Kadlec and Knight 1996; Koelsch et al. 2006). Lastly, constructed wetlands have been found to effectively remove pathogens in water through filtration in dense vegetation, sedimentation, microbial competition and predation, high temperatures, and UV disinfection (Hench et al. 2003; Nokes et al. 2003; Greenway

was isolated in feral swine near spinach fields and cattle on the Central Coast following the 2006 spinach outbreak (Jay et al. 2007). Deer and geese residing in high densities in watersheds heavily populated by humans and dairies have been identified as sources of *E. coli* O157:H7 in New York state (Somarelli et al. 2007). Despite these studies, there is still much uncertainty regarding the role of wildlife specific to the Central Coast region.

New scientific studies are already under way to investigate the role of wildlife and vegetation in food safety, as well as other sources and vectors of *E. coli* O157:H7 on the Central Coast. Although new studies will improve our understanding of risks to food safety, they will not be able to provide 100% certainty or eliminate all possible sources of contamination. Therefore, it becomes essential to weigh relative risks and focus attention and resources on the most likely sources of contamination. How current and future standards affect the risk of contamination should be evaluated. For example, conservation practices that have been shown to reduce the presence and transport of human pathogens could be an asset in meeting food safety goals. Keeping produce as safe as possible is a critical goal; however, the means to achieve this goal should be carefully investigated to insure those measures actually reduce risks of crop contamination, do not increase other human health risks as a result of environmental degradation, and are cost-effective and practical to implement.

This survey was conducted during the spring of the first growing season following the development and adoption of the California Leafy Green Products Handler Marketing Agreement. Because food safety pressures have continued to intensify — with a proliferation of food safety guidelines and increased field audits — our results likely present a conservative estimate of the on-the-ground impacts of this conflict. As standards and measures are developed to protect food safety, government and industry leaders should be conscious of how these measures affect growers as well as the environment.

Growers are concerned about being put in the unfair position of choosing between being able sell their crops or protecting the environment.

other noncrop vegetation. These actions could have impacts over large areas of land in the region. In addition, comments from growers indicated that these actions are likely to increase over time as food safety standards become more established. The survey also indicated that growers are concerned about being put in the unfair position of choosing between being able to sell their crops or protecting the environment.

Protecting human health and insuring the viability and sustainability of California agriculture demands safe food, clean water and biodiversity. However, the virulence of *E. coli* O157:H7 coupled with the consumption of raw leafy greens poses an unprecedented challenge to the produce industry. Our survey results indicate that current practices to address food safety in the field may result in environmental concessions including habitat loss, degradation and continued water-quality impairment. The removal of noncrop vegetation, for example, can include common conservation practices such as filter or buffer strips, grassed waterways, riparian

et al. 2005). Given the results of these studies, further evaluation of food safety standards requiring the removal of vegetation may be necessary.

Scientific uncertainty plays a significant role in the current conflict, particularly regarding animal sources of *E. coli* O157:H7. Although studies agree that cattle (Hancock et al. 1998; Chapman et al. 1997) and some commensal wildlife species (associated with humans) are known sources of *E. coli* O157:H7 (Fenlon 1981; Meerburg et al. 2004), most studies on pastoral wildlife (associated with natural environments) do not illustrate a substantial threat to food safety. Studies looking at pastoral small mammals and deer showed minimal prevalence of *E. coli* O157:H7 (Hancock et al. 1998; Sargeant et al. 1999; Fischer et al. 2001). Studies also indicate that there is a very low probability (0–1%) that birds associated with natural environments will carry pathogenic bacteria that could contaminate food crops (Brittingham et al. 1988; Hancock et al. 1998). More recently, *E. coli* O157:H7

The process and standards for protecting food safety in leafy greens on the Central Coast of California set a precedent that will certainly be modeled for other crops and growing regions nationwide. As of January 2008, efforts were being put forth to develop a Federal Marketing Agreement and provide the foundation for a Federal Marketing Order for leafy greens. In addition, private industry and companies that buy fresh produce continue to develop mandatory field-level food safety requirements that go beyond the currently adopted Metrics.

Based on the survey results — and ongoing efforts of the agricultural community and local, state and national organizations — there is a clear need to alleviate conflicting pressures facing growers. Resolving this conflict will require an open dialogue between scientists, environmental and food safety organizations, and leaders in the produce industry to create management standards that support both food safety and environmental stewardship. We have the opportunity and responsibility to learn from this conflict on the Central Coast, and insure that our agricultural and natural resources are successfully co-managed for human and environmental health.

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Border strips around fields, shown on a Central Coast farm, help improve water quality by filtering runoff into and off of farmland. However, such strips may also create habitat for small animals, which may be perceived as a food safety risk.

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