

## **History of the conservation of critical deer ranges in California: concepts and terminology**

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Mule deer (*Odocoileus hemionus*) are a highly visible, well-known large mammal of great recreational, conservation, and scientific interest. They are among the best-studied ungulates in North America, with a long history of conservation and management in California. Mule deer also are important because they frequently serve as a surrogate for the requirements of less well-studied species, particularly those dependent on early successional habitats. Numerous terms or phrases have been coined over the past century to categorize or describe those areas used by mule deer for all or part of their life history cycles. In this paper, we describe some of the regulatory and legislative efforts to codify the importance and protection of mule deer habitat in California and review the historical context of the origin and evolution of terms used to describe those areas, and present a standardized list of terms used to address habitats used by mule deer that, hopefully, will become commonplace and simplify conservation planning or other efforts to protect wildlife habitat.

Key words: California, *California Fish and Game*, critical range, deer range, fawning habitat, habitat, holding area, migration, mule deer, *Odocoileus hemionus*, summer range, wildlife corridor, winter range

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*“Despite the evidence to the contrary, despite the dreams of the dreamers and the schemes of the schemers, the area of wild land which may be devoted primarily to deer will decrease as the century progresses.”*

W. P. Dasmann, 1952

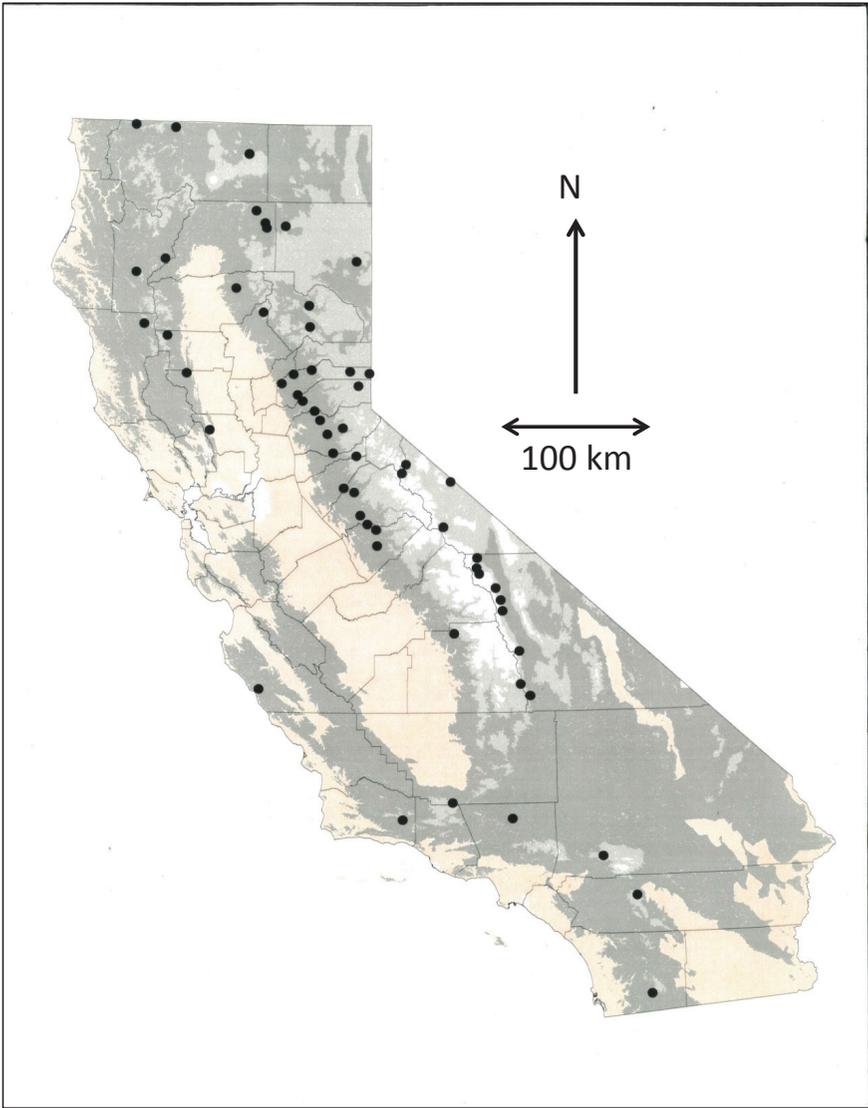
Mule and black-tailed deer (*Odocoileus hemionus* ssp.) inhabit much of the wild land in California (approximately 20 million ha [ $\approx$ 50 million acres]) and occupy a wide variety of habitats. The ranges used by deer populations were traditionally identified as winter range or summer range. As knowledge increased over many decades, use of more refined terms—such as critical winter range, key winter range, critical summer range, holding area, fawning area, and migration corridor—have been added to the jargon used to describe the landscape for deer.

The relationship between deer ranges and conservation of many wildlife species is reflected in this statement, “*While decline in deer numbers may be alarming in itself, it becomes more alarming when considered as a symptom of a common malady affecting wildlife in general... What affects one most certainly has an impact on the rest of the community*” (California Department of Fish and Game [CDFG] 1976). Because deer management in California has been a priority for many years, CDFG (beginning in 2014, the California Department of Fish and Wildlife; CDFW) has, over the decades, collected and sponsored work to identify and map seasonal ranges throughout the state. Results exist in digital format at varying scales and specificity, and are available for planning and management purposes using Geographic Information System (GIS) analyses. Information about deer ranges is frequently used in project review and conservation planning to help identify important habitats for wildlife in general.

Inconsistent interpretation of terms has resulted in some confusion, particularly in the context of land use planning efforts. Confusion in terminology is not unique to wildlife scientists, and Hall et al. (1997) recommended standardizing terms used in wildlife science. Substantial dialogue involved the labeling of ranges as “critical winter range” or, merely as “winter range.” In 1947, CDFG (then Division of Fish and Game) considered much of the west slope of the Sierra Nevada, as well as portions of the east slope, as critical range for deer. Statewide ballot initiatives in 1988 (Proposition 70) and 1990 (Proposition 117) and policy adopted by the California Fish and Game Commission (CFGC; 1984) explicitly indicated the “critical” status of deer ranges.

In this paper, the intent behind development of various terms is discussed using historical references to California deer management, policies, and state law. Conservation recommendations posited by wildlife biologists—pursuant to California Environmental Quality Act (CEQA) review of proposed developments—have long relied on deer range maps and migration routes or corridors as a basis for evaluating wildlife habitat in the absence of data for other wildlife species. Indeed, biologists have, for years, provided deer range information for local and county plans undergoing CEQA review in an effort to achieve consideration of wildlife values: about 21% of the land area acquired by the state on behalf of wildlife conservation was acquired for its value as deer range, but indirectly benefits associated species of wildlife, fish, and native plants for which the agency has trustee responsibility (CDFW 2014a).

Mule and black-tailed deer in California occupy a variety of habitats and ranges throughout their life histories (Hall 1927, McLean 1940, Longhurst et al. 1952, Zeiner et al. 1990, Cronin and Bleich 1995) (Figure 1). Seasonal ranges inhabited by deer in California have been described by various terms and meanings among wildlife professionals and, more recently, conservation planners. As managers continue to study deer distribution, abundance, movement patterns, and habitat use, we gain specific information and use such terms to infer the importance of geographic areas for deer management. For example, density estimates



**FIGURE 1.**—Approximate locations (●) of areas in California considered for the status of critical deer ranges by the California Department of Fish and Game in 1947. County lines (—) and approximate elevation zones ( $\leq 300$  m;  $>300\text{--}1525$  m;  $>1525\text{m--}2600\text{m}$ ;  $>2600$  m) also are shown. Adapted from CDFG (1947).

(i.e., deer per unit area; Longhurst et al. 1952) have been used to assess whether a range is “key” or “critical” as opposed to merely “winter” or “summer” range, and spring and fall holding areas or migration routes have been defined by monitoring groups of radio-collared deer. Some terms have been used interchangeably in studies, while other terms describing deer range have been incorporated in CDFG policy and regulations, or state law in the California Fish and Game Code.

Questions about whether a given deer range was key, critical, or neither often have arisen during planning efforts initiated by the United States Forest Service (USFS), Bureau of Land Management, California Department of Parks and Recreation, or local governments. Similarly, the inconsistent use of terms when a GIS project to map migratory deer ranges throughout California was initiated has been discussed for decades. Terms used to describe ranges are often self-explanatory and unambiguous; however, range information converted to GIS coverages—now a standard technique in natural resource management—sometimes is supported with inconsistent metadata such as labels of “key,” “critical,” or some other descriptor, absent any interpretation of intent. We submit it is desirable to revisit definitions of deer ranges to encourage use of a consistent system. We would also like to stimulate thoughts about the degree to which deer can represent wildlife habitat for use in California. Consequently, our purposes here are to (1) review California’s history regarding the use and intent of deer range terms; (2) discuss some of the broader implications of terms used to describe deer range in relation to habitat conservation; and (3) suggest use of standardized terms related to deer ranges for conservation planners. An additional, more subtle, purpose is to emphasize the historical relevance of papers published in *California Fish and Game* to the management of deer in California in this centennial anniversary volume.

## METHODS

We reviewed literature, either formally published in scientific journals or as other sources (sometimes described as “gray literature”) to establish the initial use, or evolution of terms applicable to deer management or the conservation of deer habitat in California. We also reviewed a variety of lesser-known documents, including the minutes of relevant meetings or unpublished reports to various committees, because of their historical relevance to the derivation of various terms and the resulting importance of those documents to conservation. Additionally, we reviewed regulations or legislation addressing mule deer management or conservation, and describe their implications for the persistence of mule deer and their habitat in California. Based on these sources, we derived a list of standardized terms that will be useful in simplifying land use planning efforts as well as conserving mule deer and their habitat in the future.

## HISTORICAL PERSPECTIVES ON TERMINOLOGY

Deer management in California benefits from a long history of ecological investigations. At least 117 notes, papers, or bulletins relating to California deer ecology and management published beginning in 1913 by CDFG personnel, and since 1914 in *California Fish and Game* alone, were tallied by the authors. Many of these papers—some are considered historically relevant, and even classics, in the field of wildlife conservation—were reviewed to provide the basis for describing deer ranges in California. A few additional papers on California deer published through other professional outlets such as *The Journal of Wildlife Management* or *Journal of Mammalogy* were also reviewed and incorporated herein.

*Seasonal movements and ranges.*—Observations of deer movements, trails, areas of concentration during winter, and movement patterns during hunting season prior to the mid-1900s provided the foundation for our current understanding of deer movements and seasonal ranges. Later, marking deer with dyes, flagging, ear tags, or bells was used by

wildlife managers to evaluate deer movements (Cronmiller and Bartholomew 1950, Leopold et al. 1951, Clover 1954, Jordan 1958, Taber and Dasmann 1958, Ashcraft 1961, Bauer et al. 1968). These early efforts provided little quantitative information on deer movements, but did help develop a general knowledge of seasonal ranges. From the 1970s to the present, development of radio telemetry monitoring techniques has greatly enhanced our ability to determine seasonal deer ranges and migration routes (Schneegas and Franklin 1972, Bertram and Rempel 1977, Loft et al. 1987, Kucera 1992, Monteith et al. 2011). Monitoring of deer using GPS-based telemetry collars is now underway in California, and will further enhance our knowledge of deer life history and movement patterns.

In one of the first references to deer migration, Clarke (1913) mentioned movement to higher altitudes in summer and lower altitudes in autumn. Fither (1922) described winter range along the Trinity River from, "...*Junction City to Taylor's Flat...*" as an area where the snow, "...*drives these deer into a section of country about five or six miles wide and about thirty miles in length.*" Hall (1927) indicated, "*In most parts of California the mule deer have separate summer and winter ranges. In spring, as the snow melts, the deer work up into the mountains... with the first heavy snowfall they migrate down to their winter range...*". Russell (1932), a widely read early reference on deer migration, reported that mule deer do not yard in winter as do white-tailed deer (*Odocoileus virginianus*) but, instead, choose open hillsides where the snow is not too deep to prevent moving freely about. This was the beginning of officially distinguishing some wintering areas from others.

Deer populations inhabiting ranges subject to abundant winter snow are not the only ones to exhibit seasonal movements. McLean (1930) and Longhurst and Chattin (1941) mentioned that the burro deer in the Colorado River area of California is found nearer the river during the dry seasons than during the rainy seasons when they may be in mountain ranges as far as 100 km ( $\approx 60$  mi) away. Taber and Dasmann (1958), in a comprehensive report on the black-tailed deer of California's north coast chaparral, described seasonal movements of approximately 0.6 km by deer to take advantage of warm, south-facing aspects during winter and cooler, north-facing aspects during summer.

As part of implementing deer herd management plans, biologists have conducted radio telemetry studies of varying intensity and duration on many migratory deer ranges in the state. These have resulted in largely unpublished internal reports that describe winter, transitional, and summer ranges, as well as general migration routes. However, a comprehensive statewide analysis has not been completed.

*Relative importance of seasonal ranges.*—As knowledge about deer movements increased, it became evident to investigators that not all seasonal ranges were of the same value to deer (e.g., Russell 1932). Dixon (1934), in a classic publication on California deer, implied that not all winter ranges were the same: "*I found that buck brush (*Ceanothus cuneatus*) is utilized heavily by mule deer in winter when heavy snows crowd them down into the lower winter range...*" and, "...*during January...deer...were abundant on the warm south side of the ridge.*" Dixon (1934) refers to Pilot Ridge, Mariposa County, as one of the "...*most important wintering grounds of deer in the State...*", thereby suggesting a relative ranking of winter ranges existed at least in the minds of biologists. Similarly, McLean (1940) referred to "...*four principal winter concentration areas...*" in Modoc County. Fischer et al. (1944) was one of the first in California to describe the elimination of browse needed for "critical winter periods" as a consequence of overuse on the Modoc National Forest.

The 1940s became an active period for deer management in California (Dasmann et al. 1958): there were too many of them. Deer became a “problem” of great magnitude, as 37 of 71 deer ranges surveyed during 1946–47 indicated that populations were out of balance with their habitats resulting in, “...*depletion of range and waste of deer...*” (CDFG 1947). Indeed, Storer (1932) described the problem in the early 1930s as represented by increasing damage by deer to agricultural crops as the deer population was apparently increasing. The increase in crop damage was attributed, in part, to more regulated harvest of deer with the initiation of game laws, aggressive control of predators, and the decreasing occurrence of fires on forested lands.

During the next 25 years and into the mid-1960s, deer populations in California would reach their peak and then begin a decline that CDFG attempted to moderate both through active harvest management and habitat manipulation (Longhurst et al. 1952, Dasmann et al. 1958). It was during this period that extensive habitat evaluations and deer investigations were initiated, and use of the terms “critical” and “key” became standard terminology in describing deer ranges. California’s initiation of antlerless hunting (i.e., the “1956 doe hunt” that still looms large over California deer population management), an attempt to manage the deer population rather than merely the buck harvest, was implemented to address the impact of deer on their ranges (Dasmann et al. 1958, CDFG 1963). This period of deer management brought strong public criticism of CDFG and resulted in substantial legislative change with the adoption of the “Busch Bill” in 1957, legislation that effectively turned the approval of “doe hunting” in much of California over to 37 affected counties.

*Designating deer ranges as critical.*—Perhaps the first reference to “critical” deer ranges in California was in 1947 (CDFG 1947). A “survey of the critical summer and winter deer ranges of California” was conducted to determine deer range conditions, particularly where reports of “starvation, crop and range damage, and the increase of the reported deer kill” occurred (CDFG 1947). Input was sought from throughout the state and among agencies, resulting in a list of 71 areas to be considered for critical deer range status in California (Figure 1). At the time, CDFG recommended 37 of the areas be retained as critical deer range (Table 1), and that 34 (Table 2) not remain on the list. There was no explicit definition provided by CDFG (1947) for the designation of ranges as critical; however, two areas of intent or criteria can reasonably be inferred: crop damage and habitat condition.

*Crop damage and critical deer range.*—Areas where substantial crop damage (depredation) by deer occurred appear to have been unquestionably considered critical deer range (CDFG 1947). In such areas, CDFG rarely provided deer range condition information, and none of the areas removed from the list were crop damage areas, confirming that these areas were considered critical from at least a socio-political aspect. Eleven of the 37 areas identified as “critical” were a consequence of crop damage. It is certain the designation of critical was partly used to identify specific deer ranges where conflicts with agriculture were substantial and needed to be addressed. Deer versus agriculture was an important issue that received substantial attention from CDFG and the University of California during the 1950s and 1960 (e.g., Longhurst et al. 1962), and persists in some areas today. Depredation permits issued by CDFG were one barometer of measuring conflict with agriculture, and a record 2,484 permits to kill deer were issued in 1961 (Thomson 1963). By comparison, 80 and 174 depredation permits were issued for deer in California during 2012 and 2013, respectively.

**TABLE 1.**—Deer range areas in California considered to be “critical” by CDFG (1947) and warranting retention on the list for further investigation.

ID Number	Geographic Area	County	Area (km <sup>2</sup> )	Range Condition	Influencing Factors <sup>1</sup>
1	Williams' Creek, near Covelo	Mendocino	324	Poor	G
2	Hayfork area	Trinity	Unspecified	Good	C
3	French Gulch area	Shasta	Unspecified	Fair	D, G
6	Hat Creek Rim	Shasta	129	Poor–Fair	G, W
8	Burney-Rising River	Shasta	Unspecified	Poor–Fair	Unknown
10	Secret Valley	Lassen	Unspecified	Poor	G
11	Antelope Creek	Tehama	890	Poor	G
13	Genesee Valley	Plumas	Unspecified	Unknown	C
16	Sugar Loaf Hill-Bridgeport	Nevada	18	Poor	G, D
21	Long Canyon	Placer, Eldorado	169	Fair	Unknown
23	Pacific Ranger Station area	Eldorado	154	Poor	T
26	Salt Springs Reservoir	Amador	67	Poor	T
39	Taboose Creek	Inyo	11	Undetermined	G
40	Tinemaha Creek	Inyo	22	Fair	Unknown
41	Area west of Big Pine	Inyo	32	Fair	G
43s	Tahquitz Valley	Riverside	4	Poor–Fair	Deer overpopulation
46s	Black Butte area	Glenn	246	Poor	Unknown
47	Stonyford	Colusa	392	Undetermined	C, G
48	Capay Valley	Yolo	Unspecified	Undetermined	C
49s	Monache Meadows	Tulare	640	Poor	G
50s	Buckhorn Creek	Siskiyou	322	Fair–Good	Unknown
51	Red Ledge Mine	Sierra	23	Undetermined	G
52	Round Valley	Inyo	8	Poor	Recent fire
53	Oak Creek (N. Fork)	Inyo	47	Good	Unknown
54	Sage Flat-Summit Creek	Inyo	6	Fair	Unknown
55	Haiwee grazing allotment	Inyo	14	Fair	Unknown
59	Northeast slope Mt. Tamalpais	Marin	Unspecified	Undetermined	C
60	Clear Lake-Crowder Flat-Lost Valley	Modoc	1505	Poor–Fair	G, T, other reasons
61	Ojai Valley	Ventura	Unspecified	Undetermined	C
62	Santa Clara Valley	Ventura	Unspecified	Undetermined	C
63	Leonas Valley-Ritter Bros. Ranch	Los Angeles	49	Poor	G
64	Doyle area	Lassen	531	Fair	G, mostly private
65	St. Helena area	Napa	Unspecified	Undetermined	C
66	Pebble Beach area	Monterey	Unspecified	Undetermined	C
68	Little Shasta Valley (Lema Ranch)	Siskiyou	Unspecified	Undetermined	C, G, private land
69	Placerville area	Eldorado	Unspecified	Undetermined	C
70	Kennedy Meadows	Tulare	Unspecified	Fair	G

<sup>1</sup>G = Livestock grazing overuse; C = Crop damage by deer; D = Deer range is considered decadent; W = Water development needed; H = Highway or train mortality high; P = Area in proximity to other critical area, hence recommended for later reconsideration if needed; or area should receive additional consideration for placing on list; T = Succession to timber types has reduced habitat quality.

**TABLE 2.**—Deer range areas in California originally nominated as “critical” by CDFG (1947), but not retained on that list following further review.

ID Number	Geographic Area	County	Area (km <sup>2</sup> )	Range Condition	Influencing Factors <sup>1</sup>
4	Cedar Creek	Siskiyou	Unspecified	Unspecified	G
5	Cedar Mt.	Siskiyou	206	Good	G
7	Rock Creek	Shasta	178	Good	Unknown
9	Clark's Valley-Horse Creek	Lassen	Unspecified	Good	Private land
12	Sloat area	Plumas	129	Good	H
14sp	Carpenter Valley	Nevada	47	Excellent	Unknown
15	French Point-Missouri Bar	Nevada	12	Good	Unknown
17	Goat Rock (w of Colfax)	Nevada	59	Excellent	Private land
18	Floriston-Verdi	Nevada	36	Excellent	H
19s	Tinker Knob- Sereno Creek	Placer	27	Excellent	Unknown
20	Shirrtail Creek	Placer	Unspecified	Good	Private land
21	Mosquito Ridge	Placer	16	Good	P
22	Slate Mountain	Eldorado	60	Poor	Unknown
24	Happy Valley	Eldorado	140	Poor-Good	P
25	Leonis Station	Eldorado	105	Poor	T
27	Calaveras Ranger Station area	Calaveras	99	Poor-Good	G
28	American Camp-Grant Ridge	Tuolumne	161	Poor-Good	G
29	Mt. Provo-Sugar Loaf Mt.- Jawbone Ridge	Tuolumne	148	Poor-Good	G, P
30	Kassabaum Meadow-Ferretti Ranch	Tuolumne	41	Fair-Good	C, G
31	Trumbull Peak-El Portal	Mariposa	65	Poor	Unknown
32	Buck Mdws-Moore Ck.- Bower Cave area	Mariposa	27	Poor	T
33	North Fork of the Kaweah River	Tulare	Unspecified	G-E	Park land
34s	Bodie area	Mono	Unspecified	Good	Private land
35s	Leavitt Creek	Mono	69	Excellent	Unknown
36	W. Fork Walker River	Mono	311	Poor-Good	Unknown
37sp	Rush Creek	Mono	227	Fair-Excellent	Unknown
38s	Buttermilk area	Mono	45	Excellent	Unknown
42s	Head of Santa Ana Canyon	San Bernardino	Unspecified	Good	Recent fire
44s	Laguna Mountain	San Diego	147	Poor-Good	G, recent fire
45	Big Pine Mountain	Santa Barbara	Unspecified	Good	Unknown
56s	Philbrook Reservoir area	Plumas	24	Poor-Good	G, recent fire
57s	Frazier Mountain	Ventura	61	Good	C
58	Limekiln Creek-San Antonio River	Monterey	Unspecified	Good-Excellent	Military base
67	Anderson Flat	Mariposa	155	Excellent	Unknown

<sup>1</sup>G = Livestock grazing overuse; C = Crop damage by deer; D = Deer range is considered decadent; W = Water development needed; H = Highway or train mortality high; P = Area in proximity to other critical area, hence recommended for later reconsideration if needed; or area should receive additional consideration for placing on list; T = Succession to timber types has reduced habitat quality.

Napa, Sonoma, and Santa Barbara counties were areas of highest depredation rates. Biehn (1951) attributed the crop damage in California to (1) the more than doubling of the deer population between 1900 and 1950; (2) reduction of natural feed and watering areas as a result of settlement and agricultural development; and (3) the planting of crops on historical deer ranges.

*Habitat condition and critical winter deer range.*—The majority of deer ranges identified as critical based on their habitat condition (CDFG 1947) were winter ranges. Excessive grazing and browsing by livestock and deer, and a shift from grass-forb-shrub

habitats to tree-dominated habitats were the primary reasons given for the resultant poor to fair condition of those ranges and a critical designation (Table 1, Table 2). Hence, deer ranges were considered critical, or not, based in part on their range condition. For example, the report for one area indicated, "...allotment heavily stocked, but has beautiful stand of bitterbrush. Area should be deleted from critical list." Today, biologists generally consider areas with bitterbrush (*Purshia* spp.) in any condition to be critical deer ranges. It was also implied, however, that these deer ranges had a high importance to management and conservation and this was accepted as fact by CDFG as well as by the USFS, which participated in the survey. Indeed, CDFG (1947) noted that, "*A tentative agreement with the U.S. Forest Service has been reached to reclassify critical winter deer ranges so that these areas can be set aside for wildlife use only, if the survey indicates such action as advisable*" (whether the tentative agreement was adopted by the agency is unknown to the authors); and for one area specifically, "*Because it is an important winter range of black-tailed deer, land in this critical area [regarding Antelope Creek in Tehama County] is being acquired by the state... By having control of grazing, it is hoped to restore this range to former productivity.*" This area subsequently became part of the Tehama Wildlife Area (18,964 ha) for the conservation of California's longest distance ( $\approx 160$  km annually) migratory deer herd (Longhurst et al. 1952).

CDFG (1947) did not limit the scope of designating critical ranges to specific areas, but rather took a landscape approach to wildlife and habitat management that has become popular with land management agencies and conservation advocates. For example, "...some of the areas fall into geographical units. In suggesting certain areas for detailed investigation, it becomes necessary to study the entire units rather than the individual areas. The most extensive unit is the winter range on the west slope of the Sierra Nevada Mountains. This unit of critical areas extends for about 150 miles and is primarily restricted to the yellow pine belt..." (CDFG 1947). Based on the list of areas evaluated (Table 1, Table 2), the "unit" considered critical was deer winter range from Tehama County south to at least Amador County. To the west, another unit occurred in Mendocino County, centering around Black Butte. There, three areas were considered linked by a widespread deer population, but serious range depletion by all herbivores was considered a cause of heavy mortality during severe winters.

Leopold et al. (1947) evaluated overpopulations of deer in the United States, including 12 areas identified for California, wherein overpopulations were reflected by damage or degradation of their range leading to malnutrition of the population. These areas were among the areas identified by CDFG (1947). Krausman et al. (1992) revisited the Leopold evaluation, and concluded that most of California's deer herds were still exceeding the capacity of their ranges because females are not harvested and because of a long-term decline in habitat quality.

Following the 1946–1947 survey was the initiation of "California Deer Studies" on 1 July 1947 when the CFGC, "...transferred to the University of California responsibility for conducting studies of deer populations in the state which studies would form the basis for future deer management policy. Federal Pittman-Robertson funds to the Department were made available to the University, under terms of a three year contract, to carry on these investigations" (Leopold 1948). This research project (known as Project 28-R) was administered by the university's Museum of Vertebrate Zoology, and resulted in two of the foundational works (Leopold et al. 1951, Longhurst et al. 1952) on California deer that

served as the basis for much of current management. These studies discussed the importance of seasonal deer ranges, and used the term critical as well as “key” in their descriptions.

*Designating winter range as key.*—In addition to describing ranges as “critical”, use of the term “key” has been in place for several decades and is used to describe geographic areas as well as important forage species. Dasmann (1948), using terminology likely developed for range management purposes (e.g., Stoddard et al. 1975), described “key areas” as, “...those mid-winter concentration areas that are subject to more intense cropping than those occurring elsewhere on the range.” Key areas were regarded as areas where use was heaviest; for example, “...where stocking does not exceed carrying capacity on key areas, the range will not suffer elsewhere either” (Dasmann 1948).

“Key species” for deer (Dasmann 1948) were used to help define key areas by identification of preferred deer browse. Confounding the terms however, these browse species were considered to be, “critical foods on deer ranges” and were the basis for defining what were regarded as critical deer ranges. For example, Leopold et al. (1951) identified buck brush as the most important deer food in the Jawbone area (identified as a critical range in 1946–47; Table 1) of the central Sierra Nevada, and areas where buck brush was concentrated was the “key range area.”

In northern California, the Interstate Deer Herd Committee (IDHC) was an organized effort by state and federal agencies formed in 1945 to investigate the declining deer population and habitats on the Modoc National Forest. The IDHC followed the concept of key browse or forage species such as bitterbrush to identify key areas as those places on the winter range that furnish the bulk of the winter forage. For example, IDHC (1949) noted that, “If proper balance of use against forage production is maintained within the key areas, the remainder of the range should be automatically safeguarded.” We now know that this proper balance was not maintained, and that much of the area in question has seen significant increases in western juniper (*Juniperus occidentalis*) at the expense of key browse species (Schaefer et al. 2003).

*Relationship between critical and key winter range designations.*—In the early 1950s, any distinction between the terms *critical* and *key* became blurred. Soon to be Director of CDFG, Seth Gordon (1950) recommended that the purchase of range land for big game by the recently created Wildlife Conservation Board should be, “...limited to very important key areas only” such as concentration areas for wintering deer. He further reported that, “...public land administrators are receptive to working out many adjustments in their program of land use to benefit deer. Examples of such cooperation are the reservations of winter deer ranges on the Plumas... Modoc, Lassen, Tahoe, Inyo, El Dorado, Sequoia, Klamath, Trinity, and Mendocino national forests.” Dasmann (1952) described critical deer forage as vital to the best survival of the animals on a specific range, and key areas were described as, “Too critically important to sacrifice...”. Schneegas and Franklin (1972) located and mapped the key winter range in the Mineral King area of Tulare County as a result of development proposed by the Walt Disney Corporation and USFS for recreation purposes. Browning et al. (1973) mentioned critical habitat and key habitat of deer on the west slope of the Sierra Nevada for the Railroad Flat area in Calaveras County.

A sometimes-heard perspective from deer biologists on the meaning of critical or key ranges has been that they are areas, “...where deer go to die...”, meaning that such ranges were areas of last resort for food, cover, or both during harsh winters. It implied that range condition was poor and unable to sustain deer (otherwise they wouldn't die),

resulting in die-offs, usually in the late winter period. Use of the terms key or critical in the context above supports the original concept that critical ranges are in poor shape. Leach (1956), in summarizing his investigation of deer food habits for the Great Basin deer herds in California reported, "*In severe winters, deer are forced to rely on browse species which normally are eaten less extensively... it is apparent deer will utilize whatever food is available and preference becomes secondary to survival in periods of adverse conditions.*" Leach (personal communication to E. Loft in the 1990s) indicated that deer on the Lassen-Washoe range had essentially died of starvation with full stomachs of dry annual grasses of low nutritional quality. Dasmann and Hjersman (1958) also studied deer from 1951 to 1956 in that area and reported, "*...deep snows forced deer into marginal wintering areas at lower elevations, where browse was either scarce or made up of species of sub-standard food value... unusually heavy snows pushed deer below the bitterbrush zone on some ranges.*"

Another large unit of winter range is the eastern slope of the Sierra Nevada adjacent to the Owens Valley, in Mono and Inyo counties. This unit presents a problem distinct from most of the rest of the state. In general, the deer have a comparatively unlimited summer range near and over the crest of the Sierra Nevada, but are forced onto a narrow belt of winter range at the base of the steep escarpment that characterizes much of the eastern slope. A rain shadow limits moisture on the east side (Bleich et al. 2006), and rural development and agriculture in the valley further constrain deer onto a very limited range.

To characterize terminology describing winter range, it is evident the terms critical and key were often used interchangeably. Evaluating these descriptions of deer ranges suggests that key areas and key plant species occurred within deer ranges that were, overall, considered critical. Intuitively then, a reasonable conclusion is that key areas were a subset of a broader critical deer range.

*Summer range.*—Historically, summer ranges have received less attention than winter ranges as a concern for deer in the state because of abundant long-term forest disturbances that favored deer and other species associated with early successional habitats. By default, designation of summer ranges for deer in California included the areas of deer range not considered winter range. Longhurst et al. (1952) estimated there were 217,900 km<sup>2</sup> of summer range and 138,700 km<sup>2</sup> of winter range in California. Leopold et al. (1951) estimated summer range comprised seven times the area (692 vs 96 km<sup>2</sup>) of winter range in the Jawbone deer herd range. Most summer range remains wildland managed by federal government agencies (primarily USFS and National Park Service). Such summer ranges generally are not at risk of being lost as wildlife habitat, although the quality of the habitat does change over time with plant community succession, forestry practices, fire suppression, and livestock grazing (Bleich et al. 2012). Changes in conservation goals and increased fire suppression have led to reduced levels of disturbance to California's forests. Consequently, the quality of deer habitats, both summer and winter, has declined.

Dixon (1934) observed that, "*...on our forest lands serious complications result if the range is overstocked early in the summer with domestic sheep or cattle; so that little or no green grass remains by the time the fawns should be weaned.*" Similar concerns about summer range conditions have been echoed over time (Longhurst et al. 1952, Salwasser et al. 1978, Bowyer and Bleich 1984, Loft et al. 1993, CDFG et al. 1998). Bleich et al. (2006) estimated that fawn survival to six months of age in the Sierra Nevada was approximately 28 percent, and not dissimilar from previous studies (e.g., Salwasser et al. 1978), illustrating that some combination of factors between summer and winter result in high mortality and an early reduction in potential recruitment into the population.

There were a few areas of summer range initially considered critical in the 1947 assessment, and among them was Monache Meadows and vicinity in Tulare County. This area of deer summer range reportedly had been overgrazed since at least the 1947 report, and remains an area of great concern for mule deer today, but also for the native California golden trout (*Oncorhynchus mykiss aguabonita*) (Stephens et al. 2004).

The concern for habitat conditions on summer ranges has increased over time. Forested areas of checkerboard ownership, such as north of Lake Tahoe or among the northern counties in California, have substantial private forestland that is subject to more intensive harvest strategies than neighboring public forest lands. Additionally, some of these private lands have the potential to be developed to the point they are no longer viable as habitat.

Bowyer and Bleich (1984) evaluated spring-summer ranges of deer in the mountains of San Diego County, and suggested that livestock grazing negatively influenced deer use of mountain meadows. Similarly, the negative aspects of excessive livestock grazing on key riparian habitats and its implications to deer home range size, availability of cover, and negative interspecific interactions have been reported (Loft et al. 1993, CDFG et al. 1998).

*Critical summer range.*—Critical summer range was a term that has been used in the northern Sierra Nevada by one of the Department's administrative regions (Region 2; now called the North Central Region). The term was used in the original report (CDFG 1947) with a few areas identified (Table 1, Table 2), and was further developed in a northern Sierra Nevada planning effort during the 1980s when CDFG was developing maps and overlays to assist county planning efforts. Specific areas of deer summer range had been identified—through study, investigation, and best professional judgment—as being critical for a deer herd, much like winter ranges had traditionally been identified. These areas were primarily known fawning areas and corridors or routes for migration. The intent of such designations was to identify certain areas as being more important for deer populations than the greater area of summer range. In the southern Sierra Nevada, Schneegas and Franklin (1972) previously had evaluated the Mineral King deer herd because of a proposed recreational development. In that study, they identified both key winter and key summer areas.

A difficulty with interpretation of a critical summer range designation statewide is that only one administrative region has used the term, and no statewide inventory of “critical summer ranges” exists. Hence, a look at a statewide map with these designations would misrepresent the summer range areas CDFG believed were most important for deer. No similar level of detailed consideration has occurred elsewhere in the state, although similarly important areas could likely be identified with additional studies.

*Fawning area.*—Development of wildlife telemetry in the 1970s aided immensely in the identification of specific components of deer range such as fawning areas, holding areas, and migration routes. Fawning areas are typically considered to be complexes of high quality foraging habitat, with abundant cover interspersed, where adult females give birth and nourish fawns. Meadow, riparian, and shrub types with deciduous tree (e.g., quaking aspen, [*Populus tremuloides*] or white alder [*Alnus rhombifolia*]) or conifer overstory in proximity create a complex of vegetation structures and canopies that appear to be important for hiding fawns from predators (Welker 1984, Loft et al. 1993). Schneegas and Franklin (1972) mentioned key fawning areas needing protection at critical times. Bowyer and Bleich (1984) and Loft et al. (1987) similarly described the importance of hiding cover and succulent forage on summer range fawning areas, and the implications of livestock grazing.

The terms “propagation unit” and “population center” are other terms related to fawn production, but are infrequently used. The long-term study of the North Kings Deer Herd in the Central Sierra Nevada (Ashcraft 1975, Bertram 1984) first used these terms that were adapted from Grange (1949). Propagation units are defined as places where single does find adequate food, water, cover and other necessities to rear their fawns. Population centers are defined as an aggregation of propagation units. Fawning area has become the more widely used and general term to describe such areas.

*Holding area.*—Holding areas were identified by Bertram and Rempel (1977) as those areas along migration corridors that deer used as temporary stopping points during spring and fall migrations. Spring migration is typically a gradual upward move in elevation as deer follow the receding snowlines. Deer may delay in these holding areas for a few days to several weeks, depending on the weather. Loft et al. (1987) reported radio-collared female deer giving birth on holding areas in 1983, a year when their Stanislaus National Forest summer range they had used in 1982 was covered in snow until July, and then moving up to their traditional summer ranges. Fall holding areas differ from Spring holding areas in that they appear to be situated in areas where a rapid descent in elevation is possible with the onset of a storm (Bertram and Rempel 1977). Fall holding areas on the west slope of the Sierra Nevada include areas of abundant oak (*Quercus* spp.) mast, an important food source for deer prior to winter (Loft et al. 1987). Kucera (1992) reported extensive use of Spring holding areas by mule deer on the east slope of the Sierra Nevada as they waited to ascend the steep mountains and cross the Sierra Crest to summer range. Monteith et al. (2011) evaluated the timing and factors potentially influencing deer migration to and from the winter ranges of Round Valley, Inyo and Mono counties, and elsewhere near Bishop, and concluded that a combination of weather and plant phenology influenced migration timing. Monteith et al. (2011) emphasized that during Spring deer also use holding areas on their way to summer ranges. These areas include shrub-dominated basins and flats of big sagebrush (*Artemisia tridentata*) and bitterbrush. Kucera (1992) however, did not detect or report such a holding pattern in his study area during fall where there was an abrupt elevation change between summer and winter ranges.

*Migration routes and corridors.*—Fawning areas, holding areas, and migration corridors are best delineated with the use of telemetry because they are focused, linked areas within a route between seasonal ranges. Most areas in California have been identified by site-specific investigation and telemetry studies. As a result, comprehensive information is lacking for those areas that, like critical winter ranges, likely constitute an essential part of annual life history requirements.

Of increasing concern among biologists is whether the winter ranges of California’s migratory deer herds are becoming so modified by anthropogenic processes that there have been changes in the proportion of a deer herd that are migratory versus year-round resident, such as has occurred among deer wintering in Round Valley (Monteith et al. 2014). As anthropogenic changes increase in the foothill and winter range elevations, where much of the land is privately owned, there is believed to be a consequent increase in food availability to deer through pastures, gardens, agriculture, and general landscaping. Nevertheless, increases in human populations have the potential to yield increases in the number of predators, particularly black bears (*Ursus americanus*), that are the primary cause of death among fawns born to deer from Round Valley that summer on the west side of the Sierra Crest (Monteith et al. 2014). These changes could result in higher than

previously possible densities of deer at lower elevations, while at the same time altering the proportion of migratory and non-migratory animals comprising the population on winter range. Simultaneously, long-term declines in habitat disturbance on summer ranges used by migratory deer could be reducing the amount and quality of summer range habitat, resulting in a decrease in carrying capacity for migratory deer.

Overall, the designation of holding areas, migration routes or corridors, and fawning areas on transitional range and on summer range is incomplete in California, and has largely been based on site-specific investigations. Where those areas have been identified, they provide additional information to assist in conservation and land use planning. Similarly, the designation of critical summer range has been inconsistently applied in California and is also site-specific. In terms of using the term to place a value on summer range habitat for deer, it might serve the same purpose to simply identify the types of habitats that deer rely on and prefer during summer, as they are the same riparian, wetland, and aspen habitats preferred by most terrestrial wildlife species.

#### DEER RANGE TERMINOLOGY IN POLICY AND LAW

In addition to the deer life history work, investigations and resulting biological and ecological findings, there are operational documents, policies, and laws that relate to deer ranges in the state. These policies and laws appear to interchangeably use the terms “critical” and “key” in discussing deer ranges. As a start, the CFGC adopted a Deer Management Policy in 1950 that remains in effect today. Dasmann (1953) provided an analysis of the policy, concluding in part, *“The lands on which deer occur in California may be zoned in accordance with the areas and values which predominate: Zone A- Public lands with deer priority, such as critical winter areas, where intensive habitat improvement may be justified. Zone B- Public lands where deer must fit in with other uses.”* The zone A or B designation described by Dasmann (1953), however, does not appear to have been adopted by any government entity. Additional policy in California’s deer management handbook (CDFG 1957) provided instructions for deer range surveys in that, *“...surveys will ordinarily be confined to the more important range areas, such as key winter areas, summer concentration areas, or other portions that may serve as indicators of general range use and deer population levels.”*

The landmark California Fish and Wildlife Plan (CDFG 1966) was written to identify, *“...actions which must be taken to maintain or improve California’s wildlife resources...”*. The plan discussed deer habitat improvement and stated that, *“Deer habitat improvement is usually aimed at providing more available nutritious browse during the critical time of the year... [in the] South Coast... [the] critical period is usually during the summer... [the] critical period on most migratory ranges is in the winter, although shortage of summer range forage is becoming more common on migratory ranges.”* The plan did not specifically distinguish deer ranges in terms of quality or importance.

The California Legislature, in setting the direction for the management of deer placed in law that individual deer herd plans shall *“...develop programs to maintain and increase the quality of deer habitat statewide... Emphasis shall be directed towards identifying critical deer habitat areas and the maintenance and management of such areas...”* (Fish and Game Code section 450-460). The legislation, however, was silent on whether these areas were already in critically poor condition. The Plan for California Deer (CDFG 1976) described some of the *“...human impact on deer...”* such as *“...key winter range areas were*

*inundated by the new lake...*”, indicating that evaluations of deer range had been accomplished to some level.

In the early 1980s, the CFGC and CDFG followed up the 1976 plan with a policy to identify deer herd management units and develop management plans for each of the herds. This was the initiation of >80 deer herd plans around the state. The CFGC policy for this effort stated, *“The goals of such plans shall be the restoration and maintenance of critical deer habitats to perpetuate healthy deer herds in the wild state as set forth in the appropriate deer herd management plans.”* This policy reaffirmed earlier reporting (CDFG 1947) that critical winter ranges included areas in poor (i.e., critical) condition as deer habitat. These were considered areas where intensive improvement efforts could be justified. Other lands, *“...with deer priority...”* could be included as well.

In 1988, Proposition 70—The Wildlife and Natural Areas Conservation Act—appropriated \$6,000,000 for “critical habitat areas” including “winter deer ranges”, thereby confirming that winter deer ranges are considered critical habitats. Two years later, California voters passed the California Wildlife Protection Act of 1990 (this was the controversial Proposition 117 that designated mountain lions [*Puma concolor*] as California’s only “specially protected mammal”; Bleich and Pierce 2005). As a result of passage of that act, California Fish and Game Code section 2780 states, *“Much of the state’s most important deer winter ranges have been destroyed in the last 20 years... Critical winter ranges of migratory deer in the Sierra Nevada and Cascade mountain ranges are increasingly subject to incompatible land uses. In some counties, over 80 percent of the critical winter ranges fall on these lands. The potential for incompatible land uses on these lands is a major threat to the survival of many migratory deer herds... This chapter shall be implemented in the most expeditious manner. All state officials shall implement this chapter to the fullest extent of their authority in order to preserve, maintain, and enhance California’s diverse wildlife heritage and the habitats upon which it depends.”*

These declarations by the people of California (statewide ballot propositions 70 and 117) indicated deer winter ranges are considered critical up and down the Sierra Nevada and elsewhere, and interestingly, they directed all state officials, not just CDFG officials, to preserve, maintain, and enhance those winter ranges. More recently, Proposition 84—The Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006—while not specifically mentioning deer conservation as an objective, did identify the maintenance of habitat linkages as a criterion for evaluating restoration or acquisition projects. The recent focus of wildlife conservation in California includes assessment and analyses for the identification and maintenance of wildlife connectivity in California, and specifically in the Sierra Nevada, (CDFW 2014b) that would be important to migratory deer populations.

## CONCLUSIONS

The requirements of mule deer for habitat continuity at a large scale—having winter range, summer range, and linkages connecting them—has required land managers to consider landscape-level management strategies. As early as 1913, Frank Clarke, of CDFG wrote, *“Their are many large tracts in California...that are excellent regions for game reservations. An ideal system would be to create such reservations all over the state, in close proximity that game could pass from one reservation to another. Such a commingling of individuals is apt to be of greatest necessity in the future, to prevent the natural outcome*

*of inbreeding, which might result among isolated groups of animals or even birds...".* It can be reasonably argued that if deer ranges were considered critically important in the 1940s, they are more critical now—both in terms of their physical condition and their importance to the maintenance of deer populations, as well as populations of hundreds of other wildlife species that co-occur with mule deer.

Deer are among the most studied wildlife species in California, a result of decades of interest in them as a principal game animal. For some herds, data exist as far back as the early 1900s. Because deer are so widely distributed in California, they are considered a reasonable indicator of California's changing wildland environment. Population trends of deer have been monitored over decades and reflect general habitat trends as influenced by factors such as plant succession, fire, grazing, and direct loss of habitat through human encroachment. Because of the existence of long-term data on deer populations and seasonal ranges, and when combined with their well established popularity and economic value, deer have been an important species in the environmental review process (i.e., the review of proposed projects that are subject to the California Environmental Quality Act [CEQA]). Additionally, their requirements for habitat continuity at a large scale—having winter range, summer range, and linkages connecting them—has required land managers to consider landscape-level management strategies.

Based on the papers reviewed herein, we propose a series of standardized definitions and meanings for use by deer biologists as well as conservation planners (Appendix I). Until more refined data become available, we also recommend conservation planners continue to use available mapped deer movement and seasonal data on migratory ranges of California as at least one layer in GIS analyses, and as a surrogate for other species to ensure viable deer populations and intact wildland ecosystems in California. We strongly encourage, however, the development of more robust data with respect to habitat selection, migratory movements, habitat quality, and delineation of seasonal ranges. Although the methodology is not perfect (Frair et al. 2004, Villepique et al. 2008), the advent of telemetry collars incorporating modern GPS technology (Tobler 2009) combined with archival logging and remote downloads (Millspaugh et al. 2012) now yield opportunities to develop information that can be used to better define seasonal ranges, migration corridors, or other specific geographic areas important to mule deer.

Movement information, when combined with habitat data obtained via remote sensing, can be used to build robust habitat selection models (e.g., Congalton et al. 1993, Marshal et al. 2006, Bleich et al. 2008) or to evaluate ecological hypotheses (e.g., Bleich et al. 2010, Villepique et al. 2014) that previously were impractical because acquisition of information adequate to produce meaningful results was costly and time-consuming. Thus, landsat imagery and lidar applications have the potential for great utility in wildlife and habitat investigations, conservation, and management, and *"...their value outweighs their costs when information is incorporated into products that help managers make wise decisions about natural resources"* (O'Neil et al. 2012).

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#### LITERATURE CITED

- ASHCRAFT, G. C. 1961. Deer movements of the McCloud Flats herd. *California Fish and Game* 47:145-152.
- ASHCRAFT, G. C. 1975. Deer propagation units and population centers. Federal Aid in Wildlife Restoration Report, W51-R-22, Study III, Job I.1. California Department of Fish and Game, Sacramento, USA.
- BAUER, R. D., J. T. LIGHT, AND W. R. THORNTON. 1968. Determination of the winter range of a black-tailed deer herd in the North Coast Range of California. *California Fish and Game* 54:27-32.
- BERTRAM, R. C. 1984. North Kings deer herd study. California Department of Fish and Game, Sacramento, USA.
- BERTRAM, R. C., AND R. D. REMPEL. 1977. Migration of the North Kings deer herd. *California Fish and Game* 63:157-179.
- BIEHN, E. R. 1951. Crop damage by wildlife in California: with special emphasis on deer and waterfowl. *Game Bulletin* 5:1-71.
- BLEICH, V. C., AND B. M. PIERCE. 2005. Management of mountain lions in California. Pages 63-69 in E. L. Buckner and J. Reneau, editors. *Records of North American big game*. 12th edition. Boone and Crockett Club, Missoula, Montana, USA.
- BLEICH, V. C., H. E. JOHNSON, S. A. HOLL, L. KONDE, S. G. TORRES, AND P. R. KRAUSMAN. 2008. Fire history in a chaparral ecosystem: implications for conservation of a native ungulate. *Rangeland Ecology and Management* 61:571-579.
- BLEICH, V. C., J. P. MARSHAL, AND N. G. ANDREW. 2010. Habitat use by a desert ungulate: predicting effects of water availability on mountain sheep. *Journal of Arid Environments* 74:638-645.
- BLEICH, V. C., B. M. PIERCE, J. L. JONES, AND R. T. BOWYER. 2006. Variance in survival of young mule deer in the Sierra Nevada, California. *California Fish and Game* 92:24-38.
- BLEICH, V. C., J. G. KIE, E. R. LOFT, T. R. STEPHENSON, M. W. OEHLER, SR., AND A. L. MEDINA. 2012. Managing rangelands for wildlife. Pages 75–94 in N. J. Silvy, editor. *The wildlife management techniques manual*. Volume 2: Management. Seventh edition. Johns Hopkins University Press, Baltimore, Maryland, USA.
- BOWYER, R. T., AND V. C. BLEICH. 1984. Effects of cattle grazing on selected habitats of southern mule deer. *California Fish and Game* 70:240-247.
- BROWNING, B., R. W. SCHULENBERG, AND O. BRUNETTI. 1973. Railroad Flat deer study. Wildlife Management Branch Administrative Report. California Department of Fish and Game, Sacramento, USA.
- CDFG (CALIFORNIA DEPARTMENT OF FISH AND GAME). 1947. Survey of critical summer and winter range deer ranges of California. Unpublished report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento, USA.

- CDFG. 1957. Deer management handbook. California Department of Fish and Game, Sacramento, USA.
- CDFG. 1963. Deer in California. *Outdoor California* 24(10):1-32.
- CDFG. 1966. California Fish and Wildlife Plan. Volume II. California Department of Fish and Game, Sacramento, USA.
- CDFG. 1976. A plan for California deer. California Department of Fish and Game, Sacramento, USA.
- CDFG. 1998. An assessment of mule and black-tailed deer habitats and populations in California. California Department of Fish and Game, Sacramento, USA.
- CDFW (CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE). 2014a. [Internet] Lands inventory fact sheet; [cited 10 September 2014]. Available from <http://www.dfg.ca.gov/lands/factsheet.html>
- CDFW. 2014b. [Internet] Sierra Nevada foothills wildlife connectivity modeling project [cited 10 September 2014]. Available from <http://www.dfg.ca.gov/biogeodata/projects/connectivity.asp>
- CFG (CALIFORNIA FISH AND GAME COMMISSION). 1984. Wildlife policies: deer management. California Fish and Game Commission, Sacramento, USA. Available at: <http://www.fgc.ca.gov/policy/p3wild.aspx>
- CLARKE, F. C. 1913. Investigation of the large game situation in California with special reference to deer. *Game Bulletin* 1:6-20.
- CLOVER, M. R. 1954. Deer marking devices. *California Fish and Game* 40:175-181.
- CONGALTON, R. G., J. M. STENBECK, AND R. H. BARRETT. 1993. Mapping deer habitat suitability using remote sensing and geographic information systems. *Geocarto International* 1993(3):23-33.
- COWAN, I. MCT. 1936. Distribution and variation in deer (genus *Odocoileus*) of the Pacific Coast Region of North America. *California Fish and Game* 22:155-246
- CRONEMILLER, F. P., AND P. S. BARTHOLOMEW. 1950. The California mule deer in chaparral forests. *California Fish and Game* 36:343-365.
- CRONIN, M. A., AND V. C. BLEICH. 1995. Mitochondrial DNA variation among populations and subspecies of mule deer in California. *California Fish and Game* 81:45-54.
- DASMANN, W. P. 1948. A critical review of range survey methods and their application to deer range management. *California Fish and Game* 34:189-207.
- DASMANN, W. P. 1952. Deer study handbook. California Department of Fish and Game, Sacramento, USA.
- DASMANN, W. P. 1953. An analysis of the deer management policy adopted by the Fish and Game Commission at Shasta Springs on June 27, 1950 (unpublished report). California Department of Fish and Game, Sacramento, USA.
- DASMANN, W. P., H. A. HJERSMAN, AND D. GILSENAN. 1958. California's first general either-sex deer hunting season. *California Fish and Game* 44:231-251.
- DIXON, J. S. 1934. A study of the life history and food habits of mule deer in California. *California Fish and Game* 20:181-282, 315-354.
- FISCHER, G. A., J. DAVIS, F. IVERSON, AND F. CRONEMILLER. 1944. The winter range of the interstate deer herd. U.S. Forest Service, San Francisco, California, USA.
- FITNER, C. O. 1922. Winter deer range in Game Refuge One D. *California Fish and Game* 8:205-206.

- FRAIR, J. L., S. E. NIELSEN, AND E. H. MERRILL. 2004. Removing GPS collar bias in habitat selection studies. *Journal of Applied Ecology* 41:201-212.
- GORDON, S. 1950. Some observations and recommendations on big game management and hunting in California. Report to the Wildlife Conservation Board. California Department of Fish and Game, Sacramento, USA.
- GRANGE, W. B. 1949. The way to game abundance. Scribner's and Sons, New York, USA.
- HALL, E. R. 1927. The deer of California. *California Fish and Game* 13:233-259.
- HALL, L. S., KRAUSMAN, P. R., AND M. L. MORRISON. 1997. The habitat concept and a plea for standard terminology. *Wildlife Society Bulletin* 25:173-182.
- IDHC (INTERSTATE DEER HERD COMMITTEE). 1949. Interstate winter deer range management plan. *California Fish and Game* 35:103-134.
- JORDAN, P. A. 1958. Marking deer with bells. *California Fish and Game* 44:183-189.
- KUCERA, T. E. 1992. Influences of sex and weather on migration of mule deer in California. *Great Basin Naturalist* 52:122-130.
- KRAUSMAN P. R., L. K. SOWLS, AND B. D. LEOPOLD. 1992. Revisiting overpopulated deer ranges in the United States. *California Fish and Game* 78:1-10
- LEOPOLD, A., L. K. SOWLS, AND D. L. SPENCER. 1947. A survey of overpopulated deer ranges in the United States. *Journal of Wildlife Management* 11:162-177.
- LEOPOLD, A. S. 1948. California deer studies and the function of the Deer Advisory Committee. Unpublished meeting notes, March 26, 1948. University of California, Berkeley, USA.
- LOFT, E. R., J. W. MENKE, J. G. KIE, AND R. C. BERTRAM. 1987. Influence of cattle stocking rate on the structural profile of deer hiding cover. *Journal of Wildlife Management* 51:655-664.
- LOFT, E. R., R. C. BERTRAM, AND D. L. BOWMAN. 1989. Migration patterns of mule deer in the central Sierra Nevada. *California Fish and Game* 75:11-19.
- LOFT, E. R., J. G. KIE, AND J. W. MENKE. 1993. Grazing in the Sierra Nevada: home range and space use patterns of mule deer as influenced by cattle. *California Fish and Game* 79:145-166.
- LONGHURST, W. M., AND J. E. CHATTIN. 1941. The burro deer. *California Fish and Game* 27:1-12.
- LONGHURST, W. M., M. JONES, R. PARKS, L. NEUBAUER, AND M. CUMMINGS. 1962. Fences for controlling deer damage. University of California Agricultural Experiment Station Circular 514.
- MCLEAN, D. D. 1930. The burro deer in California. *California Fish and Game* 16:119-120.
- MCLEAN, D. D. 1940. The deer of California, with particular reference to the Rocky Mountain mule deer. *California Fish and Game* 26:139-166.
- MARSHAL, J. P., V. C. BLEICH, P. R. KRAUSMAN, M. L. REED, AND N. G. ANDREW. 2006. Factors affecting habitat use and distribution of mule deer in an arid environment. *Wildlife Society Bulletin* 34:609-619.
- MILLSPAUGH, J. J., D. C. KESLER, R. W. KAYS, R. A. CITZEN, J. H. SCHULZ, C. T. ROTA, C. M. BODINOF, J. L. BELANT, AND B. J. KELLER. 2012. Wildlife radiotelemetry and remote monitoring. Pages 258-283 in N. J. Silvy, editor. *The wildlife management techniques manual*. Volume 1: Research. Seventh edition. Johns Hopkins University Press, Baltimore, Maryland, USA.

- MONTEITH, K. L., V. C. BLEICH, T. R. STEPHENSON, B. M. PIERCE, M. M. CONNER, R. W. KLAVER, AND R. T. BOWYER. 2011. Timing of seasonal migration in mule deer: effects of climate, plant phenology, and life-history characteristics. *Ecosphere* 2(4):art47. doi:10.1890/ES10-00096.1
- MONTEITH, K. M., V. C. BLEICH, T. R. STEPHENSON, B. M. PIERCE, M. M. CONNER, J. G. KIE, AND R. T. BOWYER. 2014. Life history characteristics of mule deer: effects of nutrition in a variable environment. *Wildlife Monographs* 186:1-63.
- O'NEIL, T. A., P. BETTINGER, B. G. MARCOT, W. B. COHEN, O. TAFT, R. ASH, H. BRUNER, C. LANGHOFF, J. A. CARLINO, V. HUTCHISON, R. E. KENNEDY, AND Z. YANG. 2012. Application of spatial technologies in wildlife biology. Pages 429-461 in N. J. Silvy, editor. *The wildlife management techniques manual*. Volume 1: Research. Seventh edition. Johns Hopkins University Press, Baltimore, Maryland, USA.
- RUSSELL, C. P. 1932. Seasonal migrations of mule deer. *Ecological Monographs* 2:1-46.
- SALWASSER, H., S. A. HOLL, AND G. A. ASHCRAFT. 1978. Fawn production and survival in the North Kings River deer herd. *California Fish and Game* 64:38-52.
- SCHAEFER, R. J., D. J. THAYER, AND T. S. BURTON. 2003. Forty-one years of vegetation change on permanent transects in northeastern California: implications for wildlife. *California Fish Game* 89:66-71.
- SCHNEEGAS, E. R., AND G. W. FRANKLIN. 1972. The Mineral King deer herd. *California Fish and Game* 58:133-140.
- STEPHENS, S. J., C. MCGUIRE, AND L. SIMS. 2004. [Internet]. Conservation assessment and strategy for the California golden trout (*Oncorhynchus mykiss aguabonita*) [in] Tulare County, California; [cited 10 September 2014]. Available from <http://www.tucalifornia.org/cgtic/GTCAssessmnt&Strategy9-04.pdf>
- STODDART, L. A., A. D. SMITH, AND T. W. BOX. 1975. Range management. Third edition. McGraw-Hill, New York, USA.
- TABER, R. D., AND R. F. DASMANN. 1958. The black-tailed deer of the chaparral—its life history and management in the North Coast Range of California. *Game Bulletin* 8:1-163.
- THOMSON, W. H. 1963. Deer vs. crops: the increase of depredation. *Outdoor California* 24(10):24-25.
- VILLEPIQUE, J. T., V. C. BLEICH, R. A. BOTTA, B. M. PIERCE, T. R. STEPHENSON, AND R. T. BOWYER. 2008. Evaluating GPS collar error: a critical evaluation of Televilt POSREC-Science™ Collars and a method for screening location data. *California Fish and Game* 94:155-168.
- VILLEPIQUE, J. T., B. M. PIERCE, V. C. BLEICH, A. ANDIC, AND R. T. BOWYER. 2015. Resource selection by an endangered ungulate: a multiscale test of predator-induced range abandonment. *Advances in Ecology*: in press.
- WELKER, H. J. 1986. Fawn rearing habitat of the Lake Hollow deer herd, Tehama County, California. *California Fish and Game* 72:94-98.
- ZEINER, D. C., W. F. LAUDENSLAYER, JR., K. E. MAYER, AND M. WHITE (EDITORS). 1990. California's wildlife (volume III): mammals. California Department of Fish and Game, Sacramento, USA.

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## APPENDIX I. COMMON TERMS AND RECOMMENDED INTERPRETATIONS USED TO DESCRIBE DEER, SEASONAL HABITATS, AND DEER RANGES IN CALIFORNIA, 2014

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### TERMS TO CHARACTERIZE INDIVIDUAL DEER OR THE DEER POPULATION

*Migratory*—Deer that migrate to distinct summer (in Spring) and winter ranges (in Fall). Separate summer and winter home ranges (seasonal home ranges) and migration routes can be distinguished.

*Non-migratory*—Deer inhabit a localized area and home range year-round. No migration routes exist although there may be corridors habitually used to move about the home range. Where migratory deer occur, they may share the same areas in winter, hence resident deer range may also serve as winter range for migratory deer.

*Resident*—Same as non-migratory.

*Seasonal range shifts*—Generally short movements by non-migratory (resident) deer to other parts of their home range as environmental conditions change (e.g., from south-facing slopes to north-facing slopes); within season movements to alternate winter or summer range by migratory deer as a response to changing environmental conditions.

### TERMS TO DESCRIBE SEASONAL RANGES FOR A GEOGRAPHIC AREA

*Critical Habitat*—This is an Endangered Species Act of 1973 designation. It is used to define critical habitat for threatened and endangered species, and is not recommended for any other purpose.

*Key summer range*—Uncommonly used. For migratory as well as non-migratory deer herds, this represents areas (or more appropriately habitats or geographic areas) that are considered of greatest importance to deer because of the proximate juxtaposition of necessary elements (food, water, cover). It is not recommended for use unless comprehensive data are available to define such areas.

*Critical winter range*—(1) That portion of a winter range considered most important for sustaining a deer herd. (2) That portion of the winter range in poor condition as a consequence of long-term overuse by herbivores. Portions of critical winter range may have key areas within it.

*Fawning area*—That area of summer range considered important to adult females for rearing fawns. Proximity to water, abundant cover, and high quality herbaceous and shrub forages during this nutritionally demanding and risky period of deer life history is necessary.

*Holding area*—An area (or areas) along Spring or Fall migration routes where deer delay, or hold, for at least several days. In Spring, such areas may be used for weeks if environmental conditions at summer range elevations are not “ready” in terms of snow depth or plant phenology. Holding areas can be located within an area of summer range.

*Key winter range*—An area within the winter range identified as having the most desirable forage species for deer. Additionally, it may be a localized area that is most useful and representative in indicating the level of grazing or browsing use over the winter

range as a whole. These ranges typically occur on south-facing exposures of ridges or canyons, usually areas where where snow depth is not normally limiting and there is abundant high-quality browse such as *Purshia tridentata* or *Ceanothus* spp.

*Migration corridor*—An area of suitable habitats containing migration routes between winter and summer ranges that sustain deer as they migrate. The term corridor provides an areal component beyond a linear migration route and ensures connectivity between seasonal ranges.

*Migration route*—Travel routes between distinct winter and summer ranges; typically portrayed as a line, but with no width or area associated with the route.

*Population center*—An aggregation of propagation units. This term is not widely used.

*Propagation unit*—An area of summer range and mix of habitats used for fawning; an area where adult females find adequate food, cover, and water to rear fawns. This term is not widely used.

*Summer range*—An area that migratory deer may inhabit from late Spring to early Fall. Areas at higher elevations, but typically not above timberline, in the Sierra Nevada, Cascade, and Coast Ranges are considered summer ranges.

*Winter range*—An area that migratory deer may inhabit from the Fall to Spring. For example, the elevation belt of approximately 500–1,500 m through much of the west slope of the Sierra Nevada is generally considered deer winter range.

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