Introducing change: A current look at naturalized bird species in western North America

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***Abstract*:** Both purposeful and unintentional introductions by humans of bird species to regions outside their natural ranges have long affected avifaunas, although not all populations of introduced bird species actually attain ecologically invasive status. The 24 years since the most recent comprehensive review of introductions in western North America have seen the continuation of a trend toward establishment of bird species imported for aviculture and the pet trade in urban regions and other highly altered landscapes. Concurrently, purposeful introductions (particularly of game species) have largely ceased. In the past quarter century, several patterns regarding the establishment, population trends, distributional changes, and habitat associations of non-native species have become evident. These include strong declines or total extirpation of several introduced species, notably the Crested Myna (*Acridotheres cristatus*) and Spotted Dove (*Streptopelia chinensis*), increasing numbers and diversity of parrots in urban and suburban landscapes, and the establishment or continued expansion of several estrildid, viduid, and ploceid finches, including one obligate brood parasite. Although observational databases such as eBird have greatly enhanced our ability to monitor the distribution and population sizes of introduced bird species, there is little uniformity through the West in how non-native species are monitored and at what point they are included in avifaunal lists. There is a need for implementing more thorough and uniform methods for tracking introduced bird species, including more inclusive treatment in eBird, well-defined criteria for including non-native species on state and provincial avifaunal lists, and focused studies (including citizen science-based projects) on the status, habitat associations, and biology of such species.

Keywords: anthropogenic ecology, California, feral birds, introduced birds, population monitoring, urban ecology

Introductions of non-native avian species have affected western North America's landscape for well over a century, with introduced populations of the House Sparrow (*Passer domesticus*), for example, traced back to the early 1870s (Lowther and Cink 1992). Avian introductions worldwide have been reviewed by Long (1981), and those in western North America more recently by Johnston and Garrett (1994). Until the late 20th century, introductions largely involved the purposeful establishment of game species, species with sentimental value, or those perceived as rendering ecological services (Cox 1999). Increasingly, with urban and suburban human population in portions of the West expanding greatly since the later decades of the 20th century, non-native species imported for the pet bird trade and subsequently released (primarily unintentionally) have become the dominant basis of new naturalized populations. An updated assessment building on Johnston and Garrett (1994) and emphasizing trends since the 1980s is warranted for several reasons. First is the large-scale legal importation of birds for the pet trade after World War II (Cox 1999), which continued through the 1960s and 1970s, diminished through the 1980s, and plunged particularly with the passage of the Wild Bird Conservation Act of 1992 (www.fws.gov/le/USStatutes/WBCA.pdf). It is reasonable to suppose that the sources and identities of imported bird species have changed considerably since the passage of this act, and that many or most established exotic bird species are no longer sustained or augmented by frequent liberations. A second reason for updating Johnston and Garrett is that releases of gamebird species for hunting

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declined greatly after the late 20th century, with introductions of new taxa largely curtailed and intensive management by state game agencies subsequently limited to only a few species. Third, geographically intensive and temporally inclusive databases of bird sightings (notably www.eBird.org, beginning around 2002; Sullivan et al. 2009, Wood et al. 2011) have provided far more complete information on establishment, distribution, and trends of many non-native bird species than would otherwise be available. Finally, increasing urbanization and other landscape-scale habitat conversions in western North America have influenced the distribution of many non-native bird species and in particular have benefitted a suite of tropical, subtropical, and aquatic species imported for the pet trade.

Johnston and Garrett (1994) dealt with restorations of native birds as well as novel introductions of non-native birds. Here I do not address efforts to re-establish species native to western North America, e.g., the California Condor (*Gymnogyps californianus*), Thick-billed Parrot (*Rhynchopsitta pachyrhyncha*) and Peregrine Falcon (*Falco peregrinus*). In addition, I do not treat in any detail gamebirds in the families Phasianidae and Odontophoridae native to western North America that have been introduced to localities outside their native range but within western North America, although for completeness these species are listed in Table 1. Finally, as in Johnston and Garrett (1994), I do not include the Hawaiian Islands, whose long history of avian introductions has been admirably summarized by Pyle and Pyle (2009).

Given this background, my goal is to describe the key patterns evident in the establishment, population trends, distributional changes, and habitat associations of non-native species in western North America in recent decades. I conclude with a discussion of the difficulty of documenting the initial location of an introduction, the timing and progress of naturalization and establishment of non-native bird species, and offer suggestions for improving our ability to monitor these patterns.

Methods

For this assessment, I reviewed pertinent literature, primarily since 1993, for information on the status of avian introductions in western North America. I define "western North America" as all states and Canadian provinces lying in their entirety west of the 102nd meridian, plus the Mexican states of Baja California and Baja California Sur, but excluding Hawaii. I do not include Texas in this analysis because most of that state and most of its avian introductions lie east of the core western North American region. I searched the regional reports in *North American Birds* for information on non-native species, but the limited returns for 2012–2015 (14 mentions of 8 species, apart from numerous entries for the Eurasian Collared-Dove, *Streptopelia decaocto*) made it clear that introductions are not well monitored in this journal and hence I did not attempt a complete search back to the early 1990s. The eBird database (Wood et al. 2011) was my primary source for geographical and temporal occurrence of non-native species; data outputs from eBird (mostly maps) were reviewed for all introduced species, and distributional information given below without further citation was obtained from this source. Records of many non-native species are routinely invalidated by county, regional, or statewide eBird reviewers, so they do not appear in data available at www.eBird.org. For California only, I examined all such invalidated records provided from the eBird database by special request, hence results for this state are more thorough than for other jurisdictions within the West.

I examined websites of state bird records committees in western North America, when available, to determine which introduced species are on each committee's state/provincial list. I also reviewed the committees' publicly available by-laws and/or contacted committee secretaries or other personnel to evaluate the criteria by which non-native species are included on such lists and the procedures by which new introduced species are added. See the commentary by Garrett (2004) describing the criteria for adding non-native species to the California state bird list.

For the purposes of this analysis, the term "non-native" refers to species whose natural distributions do not include western North America; all such non-native species occurring in the study region have been "introduced" by human agency (generally involving purposeful transport from the native range, then either intentional or unintentional release into the wild). Thus the terms "non-native" and "introduced" are equivalent and interchangeable for unrestrained, free-ranging birds in the region. "Naturalized" refers to introduced non-native birds that have established reproducing populations; such naturalized populations are considered "established" if they meet the criteria set forth by checklist and bird records committees. The term "feral" is applied only to naturalized populations derived from species with a history of domestication by humans.

Results and Species Accounts

In western North America non-native birds range from abundant and widely established species to more geographically restricted populations that appear to be in the early stages of naturalizing. A total of 58 species of introduced birds have been recorded collectively in the 17 state or provinces of western North American evaluated; all but 7 of these (feral domesticated species lacking population data) are listed in Table 1. Among the 58 species, I identified a "core group" of 46 with established breeding populations in at least one state or province; this group excludes species now extirpated that may never have been firmly established, feral domestic species (apart from the widespread and long-established Rock Pigeon), and species for which breeding is only conjectural.

Of the overall total of 58 species, 23 have been considered established to the point of admittance to the lists of one or more of the 17 states or provinces, although one of these species (the Crested Myna) has since been extirpated from western North America (Table 1). The number of core-group species by subregion ranged from a high of 38 in California to a low of 3 in the two northernmost subregions, Alaska and Yukon Territory.

The biogeographical origins and taxonomic affinities of introduced species in the West can be briefly summarized. Feral domestic species excluded, and analysis restricted to species that breed or had bred regularly and which persisted after the 1980s (i.e., the core group of 46 species for analysis from Table 1), introduced birds in western North America have the following general geographical origins: Eurasia (12 species), South America (8), North America (7), Mexico and Middle America (7), Indo-Malayan region (6), and Afrotropical region (6). The Australo-Papuan region is unrepresented among established exotics despite being a source for several species very popular in aviculture, such as the Cockatiel (*Nymphicus hollandicus*), Budgerigar (*Melopsittacus undulatus*), and numerous other psittacids, as well as the Zebra Finch (*Taenopygia guttata*) and other estrildids. Families represented by naturalized birds in western North America (again from the core group of 46 species) are the Psittacidae (13 species), Phasianidae (6), Odontophoridae (4), Anatidae (3), Columbidae (3), Estrildidae (3), Psittaculidae (2), Sturnidae (2), and Corvidae, Alaudidae, Pycnonotidae, Zosteropidae, Thraupidae, Cardinalidae, Fringillidae, Ploceidae, Passeridae, and Viduidae, each with one species.

Species in Table 1, plus those in additional categories of introductions omitted from it, can be grouped by the following common themes.

Introductions for Conservation Management

Several reintroductions into a species' former range and other introductions for conservation management were noted by Johnston and Garrett (1994). Augmenting the latter group is the Whooping Crane (*Grus americanus*), introduced through cross-fostering programs using Sandhill Cranes (*Antigone canadensis*) in Idaho beginning in 1975 (see www.fws.gov/northflorida/whoopingcrane/whoopingcrane-fact-2001.htm). Individuals of this small group (peaking at 33 individuals) failed to pair and reproduce (Lewis 1995), although the species is included as introduced on the Idaho state list (Table 1).

Feral Populations of Domesticated Species

Several species that have historically undergone domestication occur widely in western North America as feral populations. Of these, only the Rock Pigeon (*Columba livia*) has been recognized as established on any state/provincial avifaunal list by records committees—as it has in all jurisdictions within western North America. The African Collared-Dove (*Streptopelia roseogrisea*, the domestic forms of which were formerly known as the Ringed Turtle-Dove, *S. risoria*) had been considered established in California (McCaskie et al. 1970) on the basis of small populations in urban Los Angeles and very locally elsewhere, but this domestic form was essentially extirpated by the early 1980s and was removed from the state list (Jones et al. 1981). African Collared-Doves are still frequently noted as escapees in California and elsewhere in the West and may attempt to breed sporadically. This form is likely over-reported, as observers are not always cognizant of the frequency of pale variants of the Eurasian Collared-Dove in many western North American populations of that species (as is also the case in Britain; Goodwin 1983). T. Floyd (pers. comm.) has recently noted an expanding population of feral African Collared-Doves along the front range of Colorado, carefully distinguished from Eurasian Collared-Doves by vocal and morphological characters.

Other species maintaining local feral populations in some or most western states and provinces include the Swan Goose (*Anser cygnoides*), Graylag Goose (*A. anser*), Muscovy Duck (*Cairina moschata*), Red Junglefowl (*Gallus gallus*),

Table 1. Status of introduced birds by state or province within six regions of western North America. Species in bold represent the core group of 46 best-established naturalized species, exclusive of feral species (apart from the widespread and long-established Rock Pigeon).

Species (origin)[a]	Far North[b]		Canadian Provinces[b]		Pacific States[b]			Baja California Peninsula[b,c]		Intermountain West[b]						Southwest[b]	
	AK	YU	BC	AB	WA	OR	CA	BCN	BSC	ID	MT	WY	CO	UT	NV	AZ	NM
Anatidae																	
Mute Swan (EU)					**(e)**	**X**	**X**				**(e)**		**x**	**x**			
Egyptian Goose (AF)						**x**	**X**										
Mandarin Duck (EU)					**x**	**X**	**X**										
American Black Duck (NA)					(e)												
Phasianidae																	
Gray Partridge (EU)			**I**	**I**	**I**	**I**	**(e)**			**I**	**I**	**I**		**I**	**I**		
Chukar (EU)			**I**		**I**	**I**	**I**			**I**	**I**	**I**	**I**	**I**	**I**	**I**	**(e)**
Himalayan Snowcock (EU)															**I**		
Ring-necked Pheasant (EU)			**I**	**I**	**I**	**I**	**I**	**I**		**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**
White-tailed Ptarmigan (NA)						**X**	**I**										
Wild Turkey (NA)			**I**	**I**	**I**	**I**	**I**			**I**	**I**	**I**	**X**	**I**	**I**		
Odontophoridae																	
Mountain Quail (NA)			**I**		**I**												
California Quail (NA)			**I**		**I**					**I**	**I**		**x**	**I**		**I**	
Gambel's Quail (NA)										**I**			**I**				**NX**
Northern Bobwhite (NA)					**I**	**(E)**	**?**			**I**	**(e)**			**x**			
Gruidae																	
Whooping Crane (NA)										I	x	x					x
Columbidae																	
Rock Pigeon (feral) (EU)	**X**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**
Eurasian Collared-Dove (EU)	**I**		**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**
Spotted Dove (IM)							**I**	**I**									
Psittaculidae																	
Rose-ringed Parakeet (IM)							**X**										
Rosy-faced Lovebird (AF)							**?**						**?**			**I**	
Psittacidae																	
Blue-crowned Parakeet (SA)							**X**										
Mitred Parakeet (SA)							**X**										
Red-masked Parakeet (SA)							**X**										
Nanday Parakeet (SA)							**X**									**x**	
Monk Parakeet (SA)					**x**	**X**	**X**	**I**	**I**								**x**
White-winged Parakeet (SA)							**X**										
Yellow-chevroned Parakeet (SA)							**X**										
White-fronted Parrot (MA)							**X**										
Red-crowned Parrot (MA)							**I**										
Lilac-crowned Parrot (MA)							**X**										
Red-lored Parrot (MA)							**X**										

(*Continued*)

Indian Peafowl (*Pavo cristatus*), and Helmeted Guineafowl (*Numida meleagris*). None of these species is consistently tracked in eBird or other censuses. For example, small feral populations (some undoubtedly ephemeral) of the Helmeted Guineafowl surely occur widely throughout rural western North America, yet eBird shows validated records only for California and Alberta. Several thousand sightings of feral domestic Graylag Geese have been entered into eBird for California, but over 750 of these have been invalidated, suggesting that validation decisions for feral populations vary with the county-level eBird reviewer. Because of the dearth of information on breeding populations of these feral species, all except the Rock Pigeon are omitted from Table 1.

Table 1 (*continued*).

Species (origin)[a]	Far North[b]		Canadian Provinces[b]		Pacific States[b]			Baja California Peninsula[b,c]		Intermountain West[b]						Southwest[b]	
	AK	YU	BC	AB	WA	OR	CA	BCN	BSC	ID	MT	WY	CO	UT	NV	AZ	NM
Turquoise-fronted Parrot (SA)							**X**										
Yellow-headed Parrot (MA)							**X**										
Corvidae																	
Black-throated Magpie-Jay (MA)							**X**	**I**	**I**								
Alaudidae																	
Eurasian Skylark (EU)			**I**		**I**												
Pycnonotidae																	
Red-whiskered Bulbul (IM)							**X**										
Zosteropidae																	
Japanese White-eye (IM)							**X**										
Oriental White-eye (**IM**)							(e)										
Sturnidae																	
Crested Myna (IM)			**(E)**														
European Starling (EU)	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**
Thraupidae																	
White-collared Seedeater (MA)							**X**	**x**	**I**								
Cardinalidae																	
Northern Cardinal (NA)							**NX**										
Passeridae																	
House Sparrow (EU)	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**
Eurasian Tree Sparrow **(EU)**						(e)											
Ploceidae																	
Northern Red Bishop (AF)							**X**									**x**	
Estrildidae																	
Orange-cheeked Waxbill (AF)							**X**										
African Firefinch (**AF**)							(e)										
Bronze Mannikin (AF)							**X**										
Scaly-breasted Munia (IM)							**I**	**x**									
Viduidae																	
Pin-tailed Whydah (AF)							**X**										
Fringillidae																	
European Goldfinch (EU)							**X**										
Core Group Total	**4**	**3**	**12**	**7**	**15**	**14**	**38**	**10**	**7**	**11**	**11**	**8**	**10**	**11**	**9**	**10**	**8**

[a]Biogeographic regions of origin: AF, Afrotropical; EU, Eurasian; IM, Indo-Malayan; MA, Middle America (including Mexico); NA, North American; SA, South American.

[b]Status codes: I, accepted on state/provincial committee's list; (E), on state/provincial list as extirpated; X, naturalized breeding populations present, but species not admitted to state/provincial list; x, has bred/probably bred; N, also native in portion of state/province; (e), extirpated/never established; ?, present, but status unclear (not included in total on bottom line).

[c]Nonstandard state/province abbreviations: BCN, Baja California (Norte); BCS, Baja California Sur.

Game Species

The suite of gamebird species deliberately introduced for sport hunting was discussed by Johnston and Garrett (1994), and there is little evidence that introductions of additional species are being attempted by wildlife management agencies in western North America. Game species established from outside of North America are the Gray Partridge (*Perdix perdix*), Chukar (*Alectoris chukar*), Himalayan Snowcock (*Tetraogallus himalayensis*), and Ring-necked Pheasant (*Phasianus colchicus*). Populations of this pheasant in western North America depend on management, private land-conservation incentives, and compatible agricultural practices (Giudice and Ratti 2001). In California, Ring-necked Pheasant populations

have declined through changing agricultural practices and conversion of agricultural lands into urban, industrial, or energy-production uses, requiring that their management be revised (Hart et al. 2009). Pheasant numbers have declined in Washington (particularly in the west), and populations in parts of that state depend on supplementation from continued releases (Wahl et al. 2005).

Additional gamebird introductions from within North America, as noted by Johnston and Garrett (1994), include at least five species each of the Phasianidae and Odontophoridae (New World quail), as well as the American Black Duck (*Anas rubripes*). Free-flying escapees of the black duck have been noted locally in Washington state, though no population appears to have become established (Merrill and Bartels 2015), and most or all of these ducks probably originated from avicultural collections rather than releases for hunting (B. Tweit pers. comm.).

Wild Turkeys are widely introduced through most western states and provinces, with ongoing augmentation in many states. Populations in woodlands of oaks and other hardwoods may become an invasive nuisance, to the detriment of native galliform birds (e.g., Gillingham 2008). An effort to introduce the Dusky Grouse (*Dendragapus obscurus*) into the historically unoccupied Pinaleño Mountains in Arizona was undertaken by the Arizona Game and Fish Department as recently as 2012 (Stevenson and Rosenberg 2013).

Species No Longer Extant, or Severely Declining

Two species mentioned by Johnston and Garrett (1994) as having been introduced into western North America apparently have not had extant populations for several decades and were perhaps never truly established: the Gray Francolin (*Francolinus pondicerianus*) in Nevada and the Budgerigar in California. The latter species and the Cockatiel are routinely encountered as free-flying escapees, but have failed to establish naturalized feral populations. This illustrates that successful naturalization of psittacids is generally limited to those species that are imported in numbers directly from the wild, and that hand-raised, captive-bred species with a long history of aviculture are not likely to survive in the wild. Budgerigars did become well established in Florida in the 1970s, but those populations, heavily subsidized by seed feeders, had declined greatly by the early 1990s and were gone by 2014 (Pranty 2001, 2015a, b). Breeding of the African Firefinch (*Lagonosticta rubricata*) in Monterey County, California, was mentioned by the AOU (1998) and Roberson (2002), but this appears to have been limited to a single pair in the mid-1960s and no population became established.

Three long-established introduced species have declined to, or near, extirpation in western North America since the analysis by Johnston and Garrett (1994). The downward population trajectory of the Spotted Dove noted by these authors and by Garrett and Walker (2001) has continued to the point where the species persists only in small pockets in California. All validated eBird entries since July 2014 have been from California at a very few sites in southeastern Los Angeles County, and in the San Joaquin Valley near Bakersfield and Fresno (with no counts above single digits), and from Santa Catalina Island off Los Angeles. The species' persistence on the island suggests reasons for decline on the mainland. Predators possibly implicated in the decline of Spotted Doves in urban mainland southern California include the introduced Eastern Fox Squirrel (*Sciurus niger*), which is absent from the island, and Cooper's Hawk (*Accipiter cooperii*), only an occasional nonbreeding visitor there (Collins and Jones 2015). The range of the Eurasian Skylark (*Alauda arvensis arvensis*) has contracted on Vancouver Island (Campbell et al. 1997), and the species was apparently extirpated from Washington, where formerly established on San Juan Island, by 1998 (Wahl et al. 2005). The last individuals of the Crested Myna, formerly well established around Vancouver, British Columbia, died in 2003 (Robbins et al. 2004, Banks et al. 2005) after sharp declines in the population during the latter part of the 20th century.

Other Naturalized Species

The remaining species discussed below were imported for aesthetic reasons. Naturalization of those species imported for aviculture and the pet trade has occurred primarily from accidental and unplanned releases, which continue. An additional set of species were deliberately released into the wild for sentimental reasons or perceived ecological services; these intentional introductions occurred mainly from the mid-1800s to the mid-1900s.

Three long-established introduced species remain widespread and abundant through western North America. In addition to the Rock Pigeon noted above, the European Starling (*Sturnus vulgaris*) and House Sparrow (*Passer domesticus*)

remain ubiquitous. Gibson (2012) outlined the establishment of House Sparrows in Alaska beginning in 1987 and detailed records of vagrants to far western Alaska from introduced populations in northeastern Asia.

Waterfowl

Naturalized populations of the Mute Swan (*Cygnus olor*) persist in wetlands of the northern San Francisco Bay area in California and around Vancouver and southeastern Vancouver Island in British Columbia. Eradication efforts have largely eliminated populations in Washington and Montana (Wahl et al. 2005), while breeding pairs or small groups remain widely scattered elsewhere in the West (e.g., Utah, Colorado). The Egyptian Goose (*Alopochen aegyptiaca*) is an increasing breeding species on the coastal slope of southern California, primarily in Los Angeles and Orange counties, with a population as high as 200 birds (Pranty and Garrett 2011). The large and expanding population in southeastern Florida (Pranty and Ponzo 2014) may portend the species' establishment in California and perhaps elsewhere in the West. The establishment of a small population of Mandarin Ducks (*Aix galericulata*) in Sonoma County, California, was documented by Shurtleff and Savage (1996), and very small, ephemeral breeding populations of this species (and many other waterfowl popular in avicultural collections) currently occur through much of the West.

Doves

The most dramatic change since the publication of Johnston and Garrett (1994) is the phenomenal spread of the Eurasian Collared-Dove (*Streptopelia decaocto*) throughout western North America, well documented by Romagosa (2002), Fujisaki et al. (2010), and others. It should be emphasized that the steep decline of the Spotted Dove population in California (see above) occurred before Eurasian Collared-Doves reached the former dove's range in California, although there was some overlap between Spotted Doves and a presumed local introduction of Eurasian Collared-Doves in coastal Ventura County (and into Santa Barbara County) for a few years beginning in 1992 (Lehman 2017), raising at least the possibility of ecological interactions between the two species, and perhaps even disease transmission.

Parrots

Garrett (1997) and Pranty and Garrett (2003) provided summaries of the status of naturalized parrots in California, but little has been published on their status in the rest of western North America. The status of naturalized species in the region is briefly summarized as follows, with population and distribution data gleaned mainly from eBird.

Rose-ringed Parakeet (*Psittacula krameri*). A large population in Bakersfield in the San Joaquin Valley, California, is estimated to be well in excess of the Bakersfield Christmas Bird Count's (CBC) high count of 1394 individuals (Sheehey 2012). Small numbers remain locally in the greater Los Angeles area, particularly around Playa del Rey.

Rosy-faced Lovebird (*Agapornis roseicollis*). This African species was noted as breeding in the greater Phoenix, Arizona, area by 1987, with a great expansion through the 1990s (Radamaker and Corman 2011). A census in February 2015 recorded well over 1000 birds (K. Radamaker in litt.), and the species was added to Arizona Bird Committee's state list in 2011 (Rosenberg et al. 2017).

Monk Parakeet (*Myiopsitta monachus*). Butler (2003) detailed the history of this species in Oregon. As of the early 2000s, two small colonies persisted, near the Portland airport and about 100 km south of Portland in Scio; the species is thought not to be "self-sustaining" in Oregon. A small population persists some 40 km north of Portland in Yacolt, Clark Co., Washington (B. Tweit pers. comm., eBird data). Small numbers have recently been noted in urbanized areas of Baja California and Baja California Sur (Guerrero-Cárdenas et al. 2012, Erickson et al. 2013), with the population near La Paz in Baja California Sur having grown to about 100 individuals (Tinajero and Rodríguez Estrella 2015). A growing population in Mexicali, Baja California, began to spread into adjacent Calexico, California, early in 2017 (R. A. Erickson, M. Victoria pers. comm.). Elsewhere in California the species is sighted only occasionally, with incipient populations having been dispatched by agricultural agencies (Spreyer and Bucher 1998).

Blue-crowned Parakeet (*Thectocercus acuticaudatus*). Small numbers continue to be reported in southern California in suburban Los Angeles, primarily in the San Fernando and San Gabriel Valleys, and in far western San Bernardino County, and coastal San Diego County; no counts exceed 20 individuals (eBird data).

Mitred Parakeet (*Psittacara mitratus*). Populations around greater Los Angeles probably exceed 1000 individuals [note the editing error in Johnston and Garrett (1994), which stated a population of "several hundred thousand" rather than

the intended "several hundred to a thousand"], and a small population in the San Francisco Bay area is centered around Sunnyvale, Santa Clara County.

Red-masked Parakeet (*Psittacara erythrogenys*). Numbers in the San Gabriel and Pomona valleys of Los Angeles County, California, are in the hundreds, and significant populations also occur in San Diego and San Francisco. The latter city's population includes the well-known "Wild Parrots of Telegraph Hill" (Bittner 2004).

Nanday Parakeet (*Aratinga nenday*). The core population in southern California has spread west from the West Los Angeles/Brentwood/Pacific Palisades area of Los Angeles County through the Santa Monica Mountains to Ventura County, with several hundred birds occupying this area. Small numbers are seen in the San Gabriel Valley of eastern Los Angeles County and elsewhere in the greater Los Angeles area. Small flocks reported south of Tempe, Maricopa County, Arizona, since 2013 are said to have been present for "years," with a high count in eBird of 11 in March 2014, and 6 adults as recently as 16 July 2015.

White-winged Parakeet (*Brotogeris versicolurus*). This species was formerly established in southern Los Angeles County and in San Francisco (Garrett 1997), but there have been few reports since the 1990s. Since 2012 eBird reports of up to 15 individuals with Yellow-chevroned Parakeets in the Los Angeles Basin suggest resurgence in numbers or recolonization.

Yellow-chevroned Parakeet (*Brotogeris chiriri*). The range of this species in the Los Angeles region has expanded eastward into the Pomona Valley and western Orange County since the 1990s. The Yellow-chevroned Parakeet is now widespread throughout the Los Angeles Basin and adjacent inland valleys, probably numbering over one thousand individuals.

Red-crowned Parrot (*Amazona viridigenalis*). This continues to be the dominant psittacid in urban areas of the coastal slope of southern California, where a population of at least several thousand individuals resides. Since the review by Garrett (1997) numbers have increased in Orange County, the Los Angeles Basin and coastal Los Angeles County, the San Fernando Valley, the San Bernardino area, and San Diego County.

Lilac-crowned Parrot (*Amazona finschi*). Several hundred individuals of this western Mexico species occur in the same general areas of urban coastal southern California as the more abundant Red-crowned Parrot.

Red-lored Parrot (*Amazona autumnalis*). Flocks of up to 10 birds occur with other *Amazona* spp. in the greater Los Angeles area (east through the San Gabriel and Pomona valleys to the San Bernardino/Riverside area), in central Orange County (with a high count of 75 at a roost site in Santa Ana), and in the San Diego area. Single-digit numbers of the White-fronted Parrot (*A. albifrons*) and Turquoise-fronted Parrot (*A. aestiva*) have been consistently found among the more numerous species of *Amazona* in Los Angeles and Orange counties.

Yellow-headed Parrot (*Amazona oratrix*). A population of at least 50 individuals (from roost counts) persists in the western San Gabriel Valley of Los Angeles County, with small numbers throughout the Los Angeles Basin and in central Orange County and coastal San Diego County.

Many additional parrot species that occur in the wild as sporadic escapees might occasionally breed, e.g., the Burrowing Parakeet (*Cyanoliseus patagonus*) and various macaws (*Ara* spp.).

Passerines

Black-throated Magpie-Jay (*Calocitta colliei*). This species has been present in extreme southwestern San Diego County, California, since 1992, with nesting documented (Unitt 2004, Haas 2014). Numbers have remained low, and tracking the possible spread of individuals from this population is hampered by frequent local escapes elsewhere in urban southern California.

Red-whiskered Bulbul (*Pycnonotus jocosus*). Despite an active eradication program in Los Angeles County in the 1970s, this species is more numerous and widespread than ever in the San Gabriel Valley of eastern Los Angeles County, with some evidence of recent expansion west into the San Fernando Valley and south into the Los Angeles Basin. Large numbers are most commonly reported from botanical gardens and adjacent well-planted neighborhoods. This species is on the U. S. Fish and Wildlife Service's "Current List of Injurious Wildlife" (www.fws.gov/le/pdf/CurrentListInjuriousWildlife.pdf), intended to prevent the establishment of wildlife with potential negative economic effects. The other three species of birds on this list, the Rosy Starling (*Sturnus roseus*), Red-billed Quelea (*Quelea quelea*), and Java Sparrow (now *Lonchura oryzivora*), have not established breeding populations in western North America.

White-eyes (*Zosterops* spp.). The Oriental White-eye (*Z. palpebrosus*) was formerly established in the Balboa Park area of San Diego, California; an active eradication program for this

species in the early 1980s proved successful, with 330 birds removed from the wild (Van Way 1984). This species has not been convincingly identified in the wild in western North America since then, but white-eyes presumed to be Japanese White-eye (*Z. japonicus*, likely of the Asian mainland subspecies *simplex*) have recently become well established in coastal and central Orange County and adjacent southeastern Los Angeles County, California. White-eyes are well known as actual or potential agricultural pests and vectors for the spread of invasive plants, and they can have strong negative effects on native birds, at least on islands (Freed and Cann 2009).

Common Myna (*Acridotheres tristis*). Although there are few eBird entries for California, this species has great potential for establishment, on the basis of its history in Oceania (e.g., Hawaiian Archipelago), in continental Australia, and in Florida (Long 1981). It is not included in Table 1.

White-collared Seedeater (*Sporophila torqueola*). Small numbers of "Cinnamon-rumped" birds (nominate *torqueola*) appear to be resident in extreme southwestern San Diego County. The species has been nesting in the Cape District of Baja California Sur since at least 2007, and there are sightings for the state of Baja California as well (Erickson et al. 2013).

Northern Cardinal (*Cardinalis cardinalis*). This species exemplifies the difficulties in distinguishing among long-established introduced populations, small incipient populations, frequent observations of recent escapees, and potential vagrants from natural populations in Baja California, northwest Mexico, Arizona, and southern New Mexico. The well-known population deliberately introduced from eastern North America into eastern Los Angeles County (Long 1993) has dwindled to only a few individuals; a small breeding population of western Mexican or Baja California birds originating as escapees occurs in southwestern San Diego County (Unitt 2004). A few may breed elsewhere on the coastal slope of southern California, and presumed escapees have turned up over much of the West. Some individuals in easternmost California and southern Nevada (Meyers 2016) are almost certainly natural vagrants.

European Goldfinch (*Carduelis carduelis*). Small and apparently ephemeral breeding populations have been noted in the Los Angeles area, and escapees are noted widely in California.

Eurasian Tree Sparrow (*Passer montanus*). At least one breeding pair was noted around North Bend, Oregon, in the early 1990s but no population persisted (Marshall et al. 2003).

Northern Red Bishop (*Euplectes franciscanus*). This species (also known as the Orange Bishop) continues to be found around many river bottoms, marshes, flood basins, and weedy drainages in the greater Los Angeles region, especially along the San Gabriel and Santa Ana river systems of eastern Los Angeles and western Orange counties. Gatz (2001) noted a small breeding population in Phoenix, Arizona, but if this population persists it has gone unreported in eBird. See Bousman (2007) for a discussion of the species' status and history in the southern San Francisco Bay area. Smithson (2000) reported on some aspects of the natural history of the Northern Red Bishop and Scaly-breasted Munia in southern California. On occasion, other species of *Euplectes*, including the Yellow-crowned Bishop (*E. afer*), White-winged Widowbird (*E. albonotatus*), and Zanzibar Red Bishop (*E. nigroventris*), have been noted in southern California.

Orange-cheeked Waxbill (*Estrilda melpoda*). No long-persisting populations of this African species are known in western North America. Small but increasing numbers, including juveniles, are found regularly in the vicinity of Fountain Valley and Huntington Beach in southwestern Orange County, California, as well as in eastern and central Los Angeles County (with counts of up to 30 individuals at Huntington Central Park in Orange County in 2016 and 2017). There are eBird reports of the Common Waxbill (*Estrilda astrild*) and a few other estrildid species as well, primarily from the coastal slope of southern California.

Bronze Mannikin (*Spermestes cucullata*). Small numbers of this African species have been noted regularly in weedy river bottoms, flood-control channels, and parks in southwestern Orange County and adjacent southeastern Los Angeles County, California, in recent years, and breeding seems likely. A high count of 25 came from Fountain Valley, Orange County, in 2014.

Scaly-breasted Munia (*Lonchura punctulata*). This species has increased dramatically in southern California since the review by Johnston and Garrett (1994), with thousands of birds occurring on the coastal slope from San Luis Obispo County to San Diego County and recent sightings in Baja California as well (Erickson et al. 2013). See Bousman (2007) for status in Santa Clara County and adjacent areas of the south San Francisco Bay area. This species (formerly known as the Nutmeg Mannikin) has been added to the California state list (Pike et al. 2014) and the American Birding Association's checklist of North American birds

(Pranty et al. 2013). On the basis of niche modeling in its native and non-native ranges, Stiels et al. (2015) investigated the potential of this (and three other naturalized species) to spread. Their maps seem to show potential habitat over much of the west coast of North America, as well as extensive areas in southern and southeastern North America, but these authors "urge caution when assessing the potential spread of tropical species that have been introduced to higher latitudes."

Pin-tailed Whydah (*Vidua macroura*). Since about 2010, this African obligate brood parasite has established itself from central and southern Los Angeles County southeast through Orange County, with a high count in eBird of 83 in La Mirada, Los Angeles County. Large numbers of juveniles are noted, confirming successful breeding, and parasitism by these whydahs of Scaly-breasted Munias has recently been documented in Orange and Los Angeles counties (Garrett and Garrett 2016). Continued spread of this brood parasite will likely depend primarily on the distribution of this host (Crystal-Ornelas et al. 2017) and possibly that of the Orange-cheeked Waxbill (a known host in Africa (Lowther 2017) and Bronze Mannikin.

Discussion

Over two decades have passed since Johnston and Garrett (1994) summarized the status of introduced bird species in western North America. That period has seen sharp declines in populations of some introduced species to the point of extirpation in one (Crested Myna) and near extirpation in two others (Spotted Dove, Eurasian Skylark). Many other species have undergone great increases in numbers and geographical range, and indeed some of these species were not even mentioned in the 1994 work. Nearly all of the increasing species have been imported for the pet trade and released presumably unintentionally into the wild. Earlier introductions had been dominated by intentional releases of gamebird species or of species with perceived cultural or ecological benefits, in a time prior to awareness of the ecological effects of non-native species (Cox 1999).

Johnston and Garrett (1994) estimated that 19 of 43 (44%) successfully introduced non-native bird species in western North America were important for recreational hunting. That percentage has now been halved (10 of 46 species, 22%), with the establishment of a number of additional nongame bird species imported primarily for aviculture and the pet trade and a reduction in the number of established game species.

A listing of non-native bird species of which at least a single individual has been found in a wild state in the region would surely include hundreds of species. Pranty (2004) listed 209 such species in Florida alone (at least 62 of which have bred), and the numbers in California and the rest of western North America might well be comparable but have never been tabulated.

The results I have summarized imply that the numbers of naturalized species in California far exceed those in other western states and provinces. In part this is an artifact of my ease of access to local information and invalidated eBird entries, but the diversity in California is likely real, given the state's expansive urbanization, massive human population (and associated craving for pet birds), and large areas with a mild climate year round.

Status of Monitoring of Non-native Species

Management suitable for naturalized non-native species, ranging from tolerance to active control, is best based on knowledge of the population size and trends, distribution, and resource requirements of such species. Unfortunately, even basic information about the population status and distribution of all but the most solidly established introduced species is often lacking. Among the reasons for this is the haphazard way in which various means of monitoring avian distributions and populations (e.g., eBird, CBC, Breeding Bird Surveys [BBS], and state and provincial records committees) treat introduced species. Since continent-wide, long-term monitoring schemes such as the CBC and BBS measure broad trends and are not well suited to tracking localized, incipient populations, much of the burden of monitoring non-native birds falls to eBird. Such monitoring would benefit from consistent and proactive treatment by records committees.

Criteria for Admittance to Avifaunal Lists

Various introduced bird species have been accepted onto state and provincial avifaunal lists in western North America (Table 1). However, the criteria various committees use are not uniform. The general criteria for the inclusion of introduced species on North American avifaunal lists, as stated by the American Ornithologists' Union's North American Checklist Committee, are that a species is "considered to be established if there are persistent records for at least ten years and satisfactory evidence that [the species is] maintaining a reasonably stable or increasing population through successful reproduction" (AOU 1998).

The American Birding Association (ABA) has a stricter set of criteria (adopted in 2007; see listing.aba.org/criteria-determining-establishment-exotics/). These define establishment in terms of a "more-or-less contiguous wild population of potentially interacting individuals," a population large enough to survive normal mortality and nesting failure, sufficient reproduction to maintain or increase population levels, and lack of direct dependence on human support to maintain the population (ABA 2002). The ABA codifies a minimum period of establishment of "at least 15 years," that the identification must be documented by an archived specimen or published photograph, and that a publication describes how the criteria have been met.

Among state committees, Florida has the most explicit criteria for including introduced birds on its avifaunal list (Greenlaw et al. 2014; www.fosbirds.org/content/records-committee-rules-and-procedures). Importantly, as with the ABA, such evidence must be published in at least one scientific source, or amassed and reviewed by the bird records committee and subsequently published. Many western North American states and provinces (e.g., Arizona, California, New Mexico, Washington) follow criteria similar to those of ABA and Florida for acceptance of non-native species. Most of the remaining western records committees simply decide case by case whether a species is "well-established" or "self-sustaining," with or without a minimum period of establishment (see relevant committee web sites; also D. Faulkner, J. Marks, H. Nehls, S. Patla, C. Trost pers. comm.).

In 2014, the California Bird Records Committee established a "watch list" of naturalized bird species documented as being present and breeding in the state but which had not yet met the criteria for addition to the state list (www.californiabirds.org/watchlist.html); the creation of this list was intended to spur monitoring of the included species, and I recommend a similar approach for all records committees.

eBird: Monitoring Non-native Species

The eBird database (Sullivan et al. 2009) includes over 200 million records (ebird.org/content/ebird/news/gbif/) and can be accessed through multiple data-output tools, including maps, seasonal graphs of frequency, and specific individual records. The vast majority of records in such output tools are automatically validated by eBird "filters" designed for specific regions and seasons. To be included in the database analyzed by public output tools, records excluded by these filters must be validated by regional reviewers. Records that are invalidated do not appear in the public eBird output and can be accessed only by designated reviewers and by special request; in practice such searches are cumbersome, time-consuming, and probably seldom attempted. The use of the eBird database for the study of introduced and potentially naturalizing birds is hampered by the difficulty in accessing records that are invalidated because they are not considered to represent birds from established populations. This situation is exacerbated by uneven validation of records of introduced species, among states and provinces, and to some extent within them (at the county or regional level) as well.

The utility of eBird in tracking both established introductions and species in the early stages of naturalization can be greatly increased if all correct identifications of non-native birds are visible with the standard tools for data output. Importantly, if eBird reports of non-native species are routinely invalidated and so made invisible without special request, many or most observers will cease to report such species at all and there the data will be lost completely. A common objection to the approach of validating records of species not officially considered established is that list totals maintained by birders will be "tainted." I would simply respond that eBird's primary mission is to track bird populations in space and time (making such information publicly available through its data-output tools), and this mission should not be subservient to its secondary mission of providing a means for birders to compare their lists. I suggest that for validating entries of introduced species not already considered established (which will be listed on the relevant eBird checklist and not be flagged when reported), eBird consider the following option: "valid: species introduced/potentially naturalizing."

Among frequently reported species that almost certainly do not represent naturalized populations are cage birds commonly reared in captivity such as the Budgerigar, Cockatiel, Zebra Finch, and Yellow-fronted Canary (*Serinus mozambicus*). Should such species be ignored (i.e., invalidated if entered at all) in eBird? Since the dominant mode of introduction of non-native birds in North America in the past several decades has been through escaped or released birds imported for the pet trade, monitoring of all escapees would seem the wisest course for pinpointing naturalizations. And what of birds likely present through passage on ships, as a possible, though as yet unproven, source of naturalized populations? For example, the

Eurasian Magpie (*Pica pica*), House Crow (*Corvus splendens*), and Eurasian Tree Sparrow have been all recorded near the major port of Los Angeles/Long Beach, California, in the past 20 years.

Christmas Bird Counts: Monitoring Non-native Species

That the CBC is not a panacea for monitoring populations of introduced birds is perhaps best illustrated by the exclusion of the Rock Pigeon until the count's 74th year (1973–74)! An analysis of winter bird distribution and abundance based on CBCs (Root 1988) treated only four non-native bird species in North America (Mute Swan, Gray Partridge, Ring-necked Pheasant, and House Sparrow). Other non-natives, such as the Spotted Dove, Eurasian Skylark, and Crested Myna, were recorded at too few sites for analysis, the Rock Pigeon went unanalyzed for lack of data, and the gregarious habits of the European Starling were problematic for this study's analytic approach. As noted by Pranty (2002), "the reporting of exotics on CBCs is inconsistent and depends on the willingness of participants to count them and of compilers and editors to include them." He recommended that CBC compilers "encourage participants to pay closer attention to all exotics found in their area, not just those that are officially 'countable.'" The CBC database has potential value in tracking trends and ranges of widespread introduced birds, but generally fails to monitor localized or incipient introduced populations.

The Breeding Bird Survey: Monitoring Non-native Species

The BBS (www.pwrc.usgs.gov/bbs/) has adequately monitored trends of only a few very widespread introduced species and certain game species in open or agricultural habitats. For example, Price et al. (1995) reported trends in the Gray Partridge, Chukar, Ring-necked Pheasant, Rock Pigeon, European Starling, and House Sparrow in western North America on the basis of this program. However, a large number of naturalizing species are most commonly encountered in, or are entirely restricted to, urban and suburban landscapes where few BBS routes are sited. Furthermore, only long-established introductions are generally included in the BBS database, e.g., the only parrot included for all of California from 2000 to 2014 is a single Budgerigar (Pardieck et al. 2015)!

Improving Knowledge of Non-natives

Since well-founded avifaunal lists have great importance in the science of avian biogeography and in the psyches and strategies of birders, committees that maintain such lists need to state their criteria for the inclusion of non-native species explicitly. In particular, records committees should consider adopting criteria similar to those used by the American Birding Association and in Florida to determine if naturalized populations are sufficiently established and documented to be added to the avifaunal list. Decisions about inclusion of non-native species on avifaunal lists should be based on data such as the population sizes and trends, geographic range, and population biology of the species in question, thus requiring greater effort by observers and more consistent treatment of naturalized and establishing species in data schemes such as eBird and the Christmas Bird Counts.

I urge observers to gather and publish data about non-native birds, especially concerning their origins, taxonomy (e.g., verification of subspecies involved), genetics, population size, geographic range, movements and dispersal, breeding success, food habits, interactions with native species, etc. There is a need for basic biological information on nearly all non-native bird species in western North America. Population estimates are generally lacking and may require specialized techniques, such as early morning roost-departure counts for parrots. Basic natural history information on breeding biology, phenology of the annual cycle, dispersal, food habits, and interactions with native species are also needed. Focused citizen-science efforts would seem to hold special promise for monitoring non-native bird species, with eBird as a logical platform for recording such data. I encourage academics, nongovernmental organizations, and land and resource managers to expand the use of citizen science in these efforts. Citizen-science-based studies of the Egyptian Goose (Callaghan and Brooks 2016) and Scaly-breasted Munia (Conn et al. 2017) around Houston, Texas, exemplify the realization of this promise.

Cassey et al. (2004) and Carrete and Tella (2008) discussed the role of the wild-bird trade in the establishment of exotic species. The relationship between the pet trade (legal and illegal imports, source regions, taxa and numbers involved, status of breeding in captivity, etc.) and populations and patterns of establishment in the wild in western North America needs study. Why, for example, have *Pyrrhura* parakeets, common in the pet trade, not established populations in western North America and why are they in fact virtually never seen free flying? Genetic studies of naturalizing populations as well as known or

potential source populations could be instructive in this regard, as in a recent study of Monk Parakeets (Edelaar et al. 2015), and also provide insight into local adaptations of introduced species.

Ultimately, more comprehensive natural history information on introduced birds in western North America will aid conservation efforts for many native species. Conservation biologists debate whether naturalizing bird species should be controlled and ideally eliminated as soon as they are detected, or whether control efforts should proceed only when accumulated data suggest that the species in question might negatively affect native species of conservation concern (Bauer and Woog 2011, Edelaar and Tella 2012). Control efforts are more likely to succeed when the size of an incipient population is still very small, but scarce management funds might need to be directed toward controlling only those species that are demonstrably invasive. Currently, most naturalized bird species in western North America that have become established since the review of Johnston and Garrett (1994) are largely restricted to highly modified urban, suburban, and agricultural habitats and appear to have little potential to invade natural habitats. But many species penetrate natural habitats and potentially interact with native species of conservation concern; for example, the cavity-nesting Nanday Parakeet is now widespread in wooded canyons within the Santa Monica Mountains National Recreation Area near Los Angeles (eBird data), and Rosy-faced Lovebirds occupy saguaro-dominated desert woodlands around Phoenix, Arizona (Radamaker and Corman 2011). Therefore, careful monitoring of all introduced birds is warranted.

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