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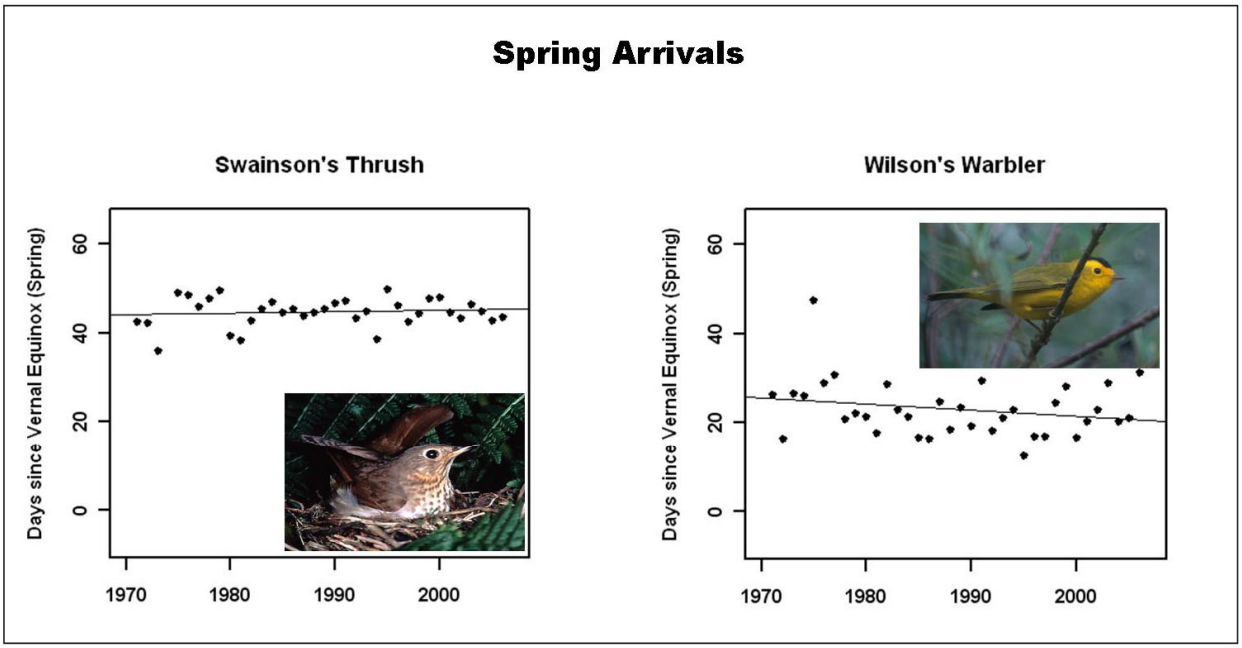
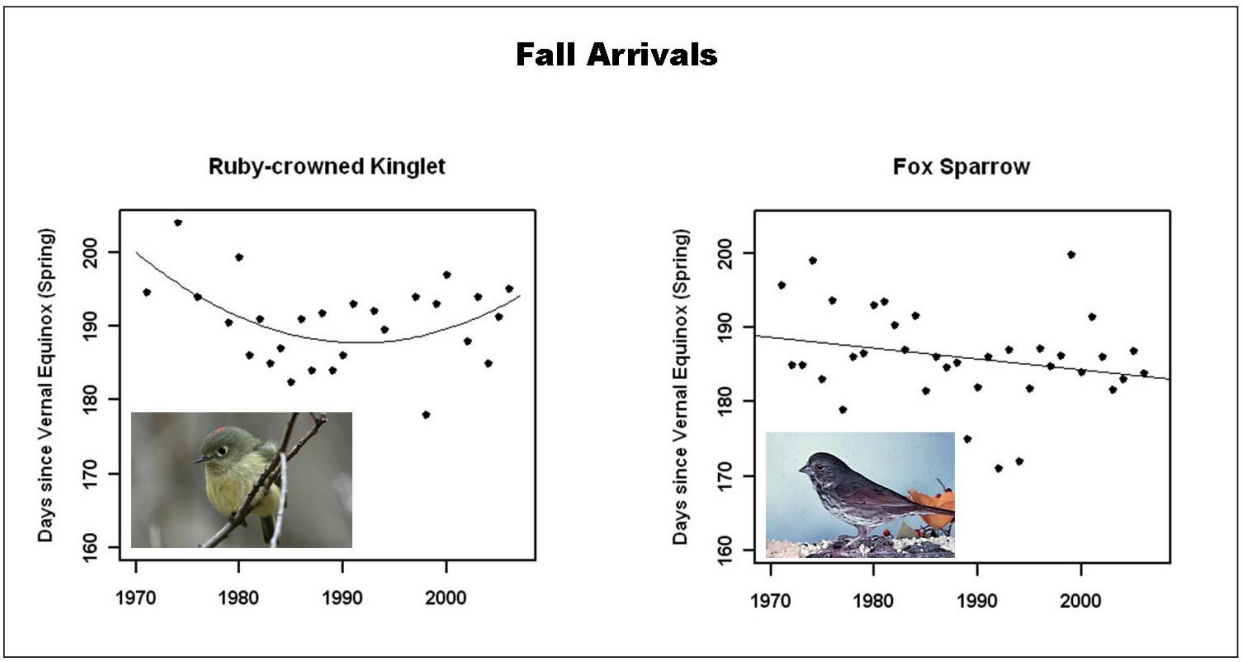
IMPACTS ON BIOLOGICAL SYSTEMS: ANIMALS
MIGRATORY BIRD ARRIVALS
Spring and fall arrivals of some migratory birds are changing





Source PRBO 2008

Photo credits: Rich Stallcup, PRBO (Wilson's Warbler); Ian Tait, PRBO (Swainson's Thrush); Rick Lewis, PRBO (Ruby-Crowned Kinglet); PRBO photo (Fox Sparrow)

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What is the indicator showing?

Trends in spring and fall arrival dates of birds migrating to their breeding (spring) and wintering (fall) grounds in Northern California vary among species. Over a 36-year period at the Point Reyes Bird Observatory's (PRBO) Palomarin Field Station on Point Reyes Peninsula, Wilson's Warblers (*Wilsonia pusilla*) have been arriving significantly earlier in recent years, a pattern shown by several other songbird species (MacMynowski et al. 2007). In contrast, spring arrival dates of Swainson's Thrushes (*Catharus ustulatus*) have been remarkably stable. Fall arrivals of Ruby-crowned Kinglets (*Regulus calendula*) from more northerly breeding grounds show a significant fit to a quadratic regression, arriving earlier from 1971 until the mid 1980s, then reversing to arrive later in the fall. Fox Sparrows (*Passerella iliaca*) show a significant long-term trend toward earlier fall arrival dates. Arrival dates for all species vary from year to year, so trends are only apparent with long-term data.

Why is this indicator important?

Evidence from studies of regional climate effects on terrestrial species shows consistent responses to warming trends. Among the responses observed is a change in the timing of migration across the Northern Hemisphere. Records of the return dates of migrant birds have shown changes in recent decades associated with changes in temperature in wintering or breeding grounds, or on the migration route (Gordo 2007, IPCC 2007, MacMynowski et al. 2007).

This indicator illustrates the value of long-term data, gathered in a systematic way, in revealing trends in spring and fall arrival dates of migratory songbirds. It adds California-specific observations to the growing body of data describing temporal patterns in bird migration. Such regional information helps improve the scientific understanding of factors that may be influencing the timing of migration and how these factors may be reflected in global trends, as well as how they vary regionally

What factors influence this indicator?

The graphs above show that clearly, different species are showing different patterns. The early arrival of some spring migrants at Palomarin is expected. Earlier arrival of spring conditions (and, consequently, available breeding habitat) has been documented over much of the Northern Hemisphere (Root et al. 2005, Parmesan 2006, for review see Gordo 2007). In contrast, less research has been performed on fall arrival of birds to their wintering grounds. Expected trends in fall arrival are less intuitive. Warmer summers may improve breeding conditions in the arctic and allow longer breeding seasons, or species might increase breeding effort and consequently delay migration to wintering grounds. Alternatively, individuals that arrive earlier on the breeding grounds in spring may complete breeding earlier and initiate fall migration earlier. Other factors, such as the phenology of forage/prey or increased inclement weather, may restrict

breeding season length, forcing species to leave and arrive on wintering grounds earlier.

Environmental conditions in the wintering or breeding grounds, on the migration route, or on the final settling location, all of which affect arrival times, may in turn be affected by factors operating on multiple spatial scales. The variety of factors and the multiplicity of temporal and spatial scales at which birds operate during migration undoubtedly contribute to the considerable inter-annual variation in arrival dates.

Broad-scale Climate Indices

Broad-scale hemispheric or continental indices can be used to provide a quantitative categorization of regional climate conditions that a species may respond to throughout the entire species' distribution (e.g. Root 2003, MacMynowski et al. 2007). These climatic conditions can directly influence a species' collective decision to initiate migration. Examples include North Atlantic Oscillation, Pacific Decadal Oscillation and El Niño Indices such as the Multivariate El Niño Index and Southern Oscillation Index.

Regional Conditions

Mirgating birds respond strongly to atmospheric pressure cells and the passage of fronts, which can accelerate or hold back their migratory movements. Within a given year, the arrival date of a species may depend on the proximate occurrence of weather patterns on the migratory route.

Local Conditions

Local weather conditions, such as recent rainfall and temperature, can create unique local breeding conditions that vary from place to place across the landscape. These conditions may influence the decision of individuals to remain within the area of study and be available for capture.

Habitat Trends

Birds are not undertaking migratory movements within a static environment. The vegetation communities that are the template for songbird habitat in terrestrial ecosystems are continuously changing. These changes are driven by normal ecological succession processes and, more recently, changes in land use and climate change. These forces result both in shifts in vegetational phenology (and consequent shifts in the emergence and abundance of invertebrate prey of birds) and in plant distributions across climate gradients (such as elevation).

Technical Considerations:

Data Characteristics

Data type - The raw data for this analysis consist of records of individual birds banded in mist nets using a standard protocol (Ralph et al. 1993). The Palomarin Field Station is in north-central coastal California, near the southern end of the Point Reyes peninsula, within Point Reyes National Seashore (37°56´ N, 122°45´ W). Continuous data

collection began in 1971. In general, sampling effort has remained relatively stable, although inclement weather can restrict survey efforts.

Data used for analysis –Only those birds known to be in their second year or greater (i.e. after-hatch-year) are included. The species selected for this analysis were chosen for their documented sensitivity to climate and weather (MacMynowski et al. 2007; PRBO unpublished data) and high capture rates. For the analysis of spring arrivals, the five most frequently captured species that are expected to be responsive to climate and weather in the spring were selected: Black-headed Grosbeak (*Pheucticus melanocephalus*), Warbling Vireo (*Vireo gilvus*), Wilson's Warbler, Swainson's Thrush, and Orange-crowned Warbler (*Vermivora celata*). Fall species selected are Golden-crowned Sparrow (*Zonotrichia atricapilla*), Fox Sparrow, Ruby-crowned Kinglet, and Yellow Warbler (*Dendroica petechia*). The graphs illustrate species for which there were significant trends.

Response Variable – Within each year only the first quartile (25%) of captures for each species was used in this analysis. This increased the probability that birds captured and used in the analysis were birds that had recently arrived at the location. Within this subset of the data, the mean date of capture was used as the estimated arrival date for the species. Mean arrival date can remove bias associated with a trending population size (Miller-Rushing et al. 2008). In order to remove bias that changes in timing of actual spring (vernal equinox) can have on Julian or calendar dates (Sagarin 2001, see Miller-Rushing et al 2008), arrival date were transformed to "days since vernal equinox."

Strengths and Limitations of the Data

These data provide a long-term record of bird migration phenology. Efforts have been strictly standardized since 1979 and less rigidly standardized from 1971-1978.

Effects of change in effort or population size – A change in monitoring effort was expected to produce a similar bias to that of change in population size of a species. It has been shown previously that population sizes can affect first arrival dates (Miller-Rushing et al 2008). By using mean arrival date of the first quartile of captures, the impact that population size can have on arrival distribution is reduced.

Location is terminus of migration – Because the Palomarin Field Station is not a location along the migratory pathway for all the individuals captured of these species but rather is the final stopping location (either for breeding or wintering) for some to many of them, depending on the species, it is possible to bias results toward later dates, because there is increased probability that birds being captured have been present at the location for some period of time. We have attempted to minimize this by restricting our analyses to the initial 25% of all captured birds.

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