Protocol for Golden Eagle Occupancy, Reproduction, and Prey Population Assessment

American Eagle Research InstitutE

30 Years of Bald and Golden Eagle

Research In the USA and Mexico

Inventory of Nesting Habitat

And Existing Nest Structures

ORA Protocol is Similar for Bald Eagles

Bald Eagles Are Somewhat Easier to Survey

Primarily Nest Along Riparian Corridors

Golden Eagles are Scattered

In the Landscape

Survey Cliff Nesting Habitat

In the Fall from a Helicopter

GPS and Photograph Nest Structures

1) To Aid in Occupancy Surveys
2) Nest Clusters as Initial Separation of Potential Breeding Areas

Ground Surveys of Tree Nesting Habitat in Winter

Aerial Surveys Alone of Tree Nesting Habitat May Miss
Up To 75% of Nest Structures

Potential Sources of Bias and Error

1) Aircraft Type: a) Planes cannot perform as well as Helicopters and nests will be missed on survey (GE – Up to 97%, BE – Frasier et al. 1983).
   b) Small helicopters cannot perform in windy conditions and nests will be missed.
   c) Bell Long Ranger with pilot and 3 observers is ideal.
2) Helicopter Speed: 10-20 knots. 15 knots is ideal.
3) Pilot and Helicopter ability to hover and maneuver in tight canyons and along cliffs.
4) Flight Elevation: Low, Middle, and Upper Levels of Large Cliffs.
5) Direction of Travel: Some nests are only visible from one direction.
6) Glare from sun.
7) Motion Sickness: Observer is not focused.
8) Observer Experience: Five areas in CA, NV, and AZ surveyed by 2 firms
   Nest Clusters Missed: 24%
   Total Nests Missed: 67%
   Occupied Sites Missed: 66%

Terminology – Postupalsky 1974

1) Breeding Area – An area containing one or more nests within the range of one mated pair of birds.

2) Occupied BA – An area containing a nest at which:

a) Young were raised;
b) Eggs were laid;
c) An adult was observed sitting low in the nest, presumably incubating;
d) Two adults were observed perched on or near the nest;
e) An adult and a bird in immature plumage were observed at or near the nest, if courtship behavior occurred; or,
f) Recent repairs (fresh sticks or lining), mute, or feathers were visible at or near the nest.

3) Unoccupied BA – An area containing a nest at which none of the above indicators was observed.

Terminology – Postupalsky 1974

4) Active Nest – A nest in which eggs have been laid.

5) Failed Nest – An Active nest in which the eggs did not hatch, or the young died before reaching an advanced stage of development.

6) Successful Nest - An Active nest in which at least one young survived to an advanced stage of development.

7) Nest Success – The proportion of Occupied BAs which produce at least one young to an advanced stage of development.

Nest Success (%) = # Successful Nests / # Occupied BAs

8) Mean Brood Size – The number of young produced (fledged) per Successful Nest.

Mean Brood Size = # Young Produced / # Successful Nests

9) Productivity – The number of young produced (fledged) per Occupied Breeding Area.

Productivity = # Young Produced / # Occupied BAs

Terminology – Steenhof and Kochert 1982

An Advanced Stage of Development (as in Items 5, 6, and 7 of Postupalsky's Terminology) equates to 80 percent of fledging age.

Golden Eagles typically fledge at 10 weeks of age, so 80% of fledging age would be 8 weeks.

Assess Breeding Area Occupancy

Occupancy Surveys in Winter

During Eagle Courtship Behavior

Golden Eagle Courtship Behavior

1) Undulation Flights
2) Nest Building
3) Copulation
4) Pair Soaring

Serviceable Breeding Locations

Because Serviceable Breeding Locations can be a limiting factor in raptor populations (Hunt 1988), it is advantageous for pairs to remain on territory even when prey conditions are unfavorable for reproduction (Newton 1979).

Occupied Breeding Area

Nest and Mated Pair of Eagles

Occupancy Data are Critical to Population Demography and Health

Allows Further Separation of Potential Breeding Areas located during Nest Inventory Flights

Potential Sources of Bias and Error

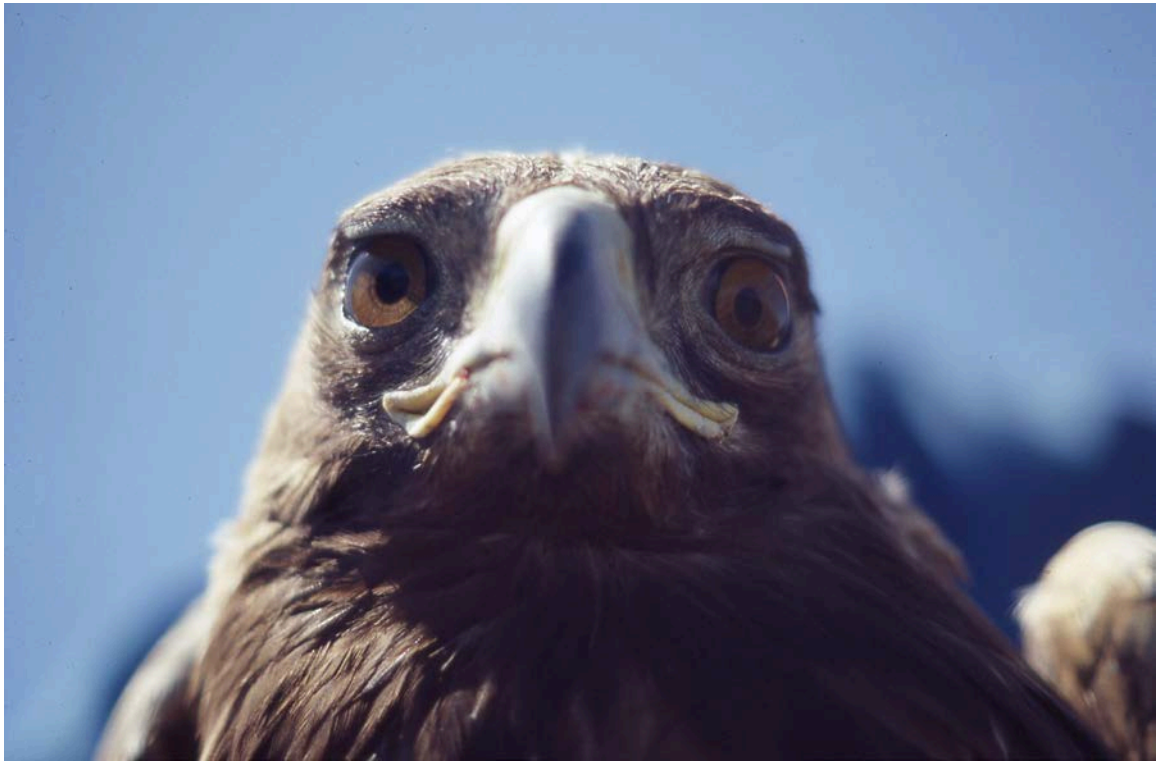
1) Occupancy Surveys not performed in winter may miss pairs that:
   a) Do not lay eggs; or,
   b) Move to new or alternate nests.

2) Where nesting density is high, it is often easier to verify occupancy than in habitats where home ranges are larger and pairs are spaced farther apart.

3) Pair could be anywhere during your site visit, including soaring very high

4) Minimum of 4 Site Visits of 4 hours each before assigning a breeding area Unoccupied Status.

Incubation Surveys



Golden Eagles Lay 1-3 Eggs

Typically in mid-February in the Southwest

Incubation Surveys ASAP Following Egg Laying

Golden Eagles have a 45 Day Incubation Period
(Note the size of the Nest and Ledge)

Potential Sources of Bias and Error

1) All pairs do not lay eggs at same time, so may need repeat visits to some breeding areas.

2) Missing pairs that:
    a) Fail early in the incubation stage;
    b) Do not lay eggs; or,
    c) Move to new or alternate nests.

Nestling Surveys

First Nestling Survey 2-3 Weeks

After Hatching if from Helicopter

Brooding Adult Will Sit Higher

On the Nest than When Incubating

Young are Capable of

Thermoregulation at 3 Weeks of Age

Second Nestling Survey At 8-10 Weeks of Age

Golden Eagles Typically Fledge at 10 Weeks

Potential Sources of Bias and Error

1) Missing young that die early in the nestling stage.

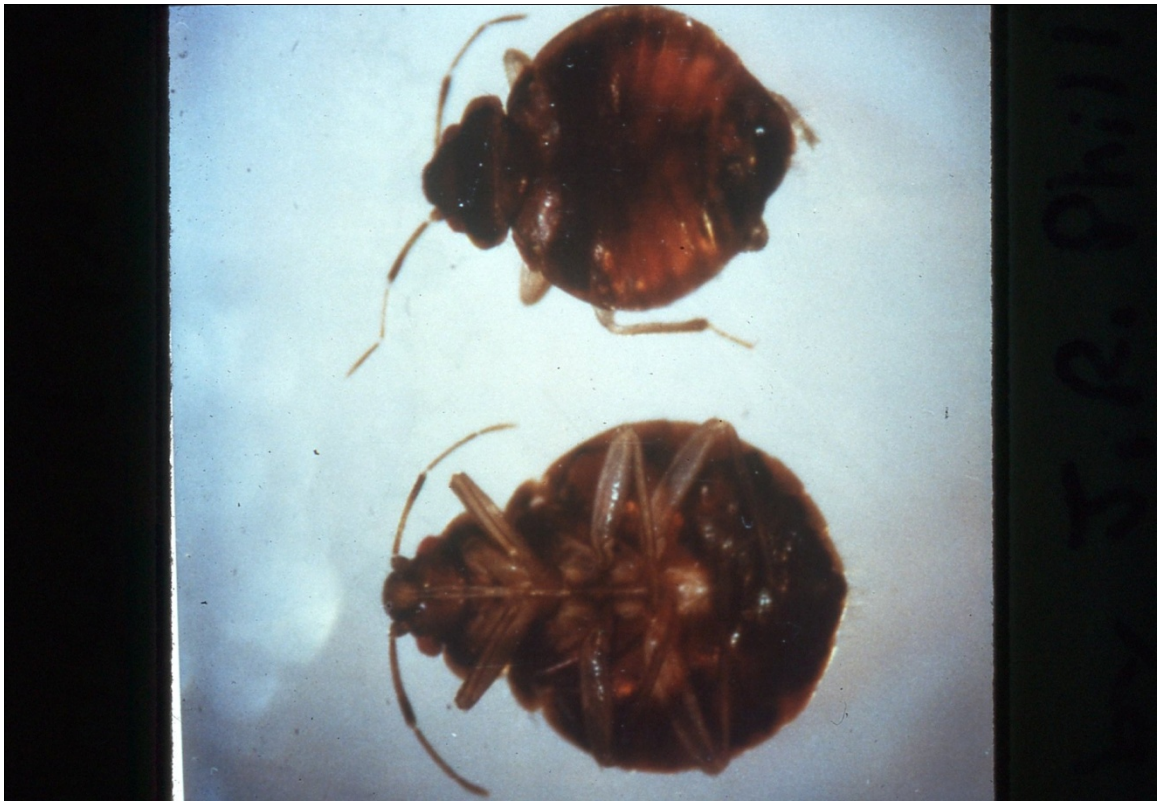
Siblicide May Occur in First 2 Weeks

If Prey is in Short Supply

Nestling Fatalities May Occur

From Heat Stress or Nest Parasites

Possible Nest Parasites Include



Mexican Chicken Bugs (Cimicidae)

Ticks of the Genus Argas can Result

In Tick Paralysis and Weaken Young

Nestling Fatalities also Result From

Great Horned Owls, Bobcats, Eagles

Prey Population Assessment

Golden Eagle Diet Varies Widely Across the Western U.S.

Mammals generally compose 80%-90% of the diet

Prey of Primary Importance

Leporids (Hares and Rabbits)

Sciurids (Ground Squirrels, Prairie Dogs, Marmots)

Gallinaceous Birds (Pheasant, Grouse, Ptarmigan)

Carrion (Large Ungulates) Especially in Winter

Cyclic Prey Populations

Population peaks followed by drastic reductions
Jackrabbits
Snowshoe Hares
Willow Ptarmigan

Golden Eagle productivity tends to cycle with prey,
But this should not effect Occupancy of
Breeding Areas

Fossorial Prey Populations

Ground Squirrels
Prairie Dogs
Marmots

1) Reductions in ground squirrel and prairie dog numbers can stem from heavy rains that flood burrows during hibernation or aestivation.
2) Plague epizootic can reduce prairie dog numbers by 80%-90%.

If fossorial animals are a primary prey species, Golden Eagle productivity may be reduced in years of low prey numbers, But this should not effect Occupancy of Breeding Areas

Black-tailed Jackrabbits

Black-tailed Jackrabbits

1) Primary prey species of golden eagles in many areas of the western U.S.
2) Can produce multiple litters (4-5) each year.
3) Population reaches peak numbers in fall after the breeding season.
4) Females from the first litter can reproduce in the same season.
5) Young remain in warren for first 4-6 weeks.

Black-tailed Jackrabbit Population Cycles

1) Peaks at 8-10 year intervals in Utah (1950s-1970s)
2) Peaks at 7-12 year intervals in Idaho (1970s-1990s)
3) Peaks across the western U.S. in 2006 –2007 possibly hint at potential for west-wide cycles.
4) Peak in AZ in 2007, followed by crash in 2010.
5) Peak in AZ and NV in 2015 (or 2016) indicate 8-9 year interval.

Black-tailed Jackrabbit Survey Methods

1) Drive Counts - Too labor intensive
2) Road-kill Counts – Good for trend estimates (Smith and Murphy 1979, M. Lockhart pers. comm.)
3) Spotlight Line-Transect Surveys (Smith and Nydegger 1985) Good Method for estimation of animal density

Spotlight Line-Transect Surveys

1) Vehicle survey at night on two-track roads (if possible)
2) Slow Speed – 5-10 MPH
3) Driver records rabbits on center-line
4) Observer in bed of truck spotlights rabbits within 180 degree arc each side of centerline.
5) Record odometer reading and perpendicular distance to animal. (Pacing or Measuring).

Modification to Spotlight Line-Transect Surveys

1) Both observers within cab, searching each half of the area. (For Safety and Cold Weather)
2) Record GPS location on road perpendicular to animal.
3) Use Nikon Laser Range-Finders to estimate distance to animal.
4) Survey within 3 nights of new moon (7 day period).
5) Start at least one hour after sunset, and finish at least one hour before first-light.
6) Avoid adverse weather (rain and wind), as animals are not active.
7) Survey transects monthly during April to October.

California Ground Squirrels

California Ground Squirrels

1) Primary prey species of golden eagles in the Altamont Pass and Diablo Range of California.
2) Breeding Season is December to February.
3) Female in estrus for 4-5 hours during one day each year.
4) Single litters sired by multiple males (89%).
5) Gestation Period of 28 to 30 days.
6) Mean Litter Size of 7 young.
7) Young emerge during March to June at 6-7 weeks of age.
8) Most females in the population breed, and over 90% are successful.

California Ground Squirrel Survey Methods

1) Visual Surveys – Inaccurate – Social behavior and alarm calls result in animals entering burrows, and young may remain in burrows for days.
2) Burrow Counts – Inaccurate - Fitch (1948) found 17 holes and 7 burrow systems for each ground squirrel.
3) Mark-Recapture – Provides the most accurate estimate of animal numbers, but is too labor and cost intensive.
4) Point Counts and Road Transects – Can provide a relative estimate of density for comparison between areas.

California Ground Squirrel Point Count and Road Transect Survey Methods

1) Remain in vehicle during counts.
2) Conduct counts during periods of maximum surface activity.
3) Surface activity is generally bimodal in summer (5-9AM + 4PM to dusk)
4) Point Counts – Count number of ground squirrels several times and record the highest count.
5) Road Transect Survey
    a) Transects on gravel or dirt roads through ground squirrel habitat.
    b) Travel at slow speed (5-10 MPH)
    c) Two observers count ground squirrels on each side of road.
6) Avoid counts during adverse weather (wind, cold fog, rain) as this limits surface activity.

* Relative ground squirrel densities (low, medium, high) correlated strongly with golden eagle location data.

Prairie Dogs

Prairie Dogs

1) 5 Species in North America – Black-tailed, White-tailed, Utah, Gunnison's, and Mexican.
2) Currently occupy less than 2% of historical range (Miller et al. 1994).
3) May be an important component of golden eagle diet in areas where colonies are large.
4) May be important for certain pairs in regions of small or scattered colonies
5) Compose over 90% of the diet of endangered Black-footed Ferrets.
6) Plague can result in an 85%-90% mortality rate during 2-4 months.
7) Plague resulted in significant retraction of the range of Gunnison's prairie dogs during 1988-2001 (Fitzgerald 1993, Wagner and Drickamer 2003).

Prairie Dogs

1) Emerge from hibernation during February to March.
2) Breeding Season is March to May.
3) Black-tailed – Sexually mature in two years.
4) White-tailed, Utah, Gunnison's – Sexually mature in one year.
5) Female in estrus for 4-5 hours during one day each year.
6) Single litters sired by multiple males.
7) Average Gestation Period is 30 days.
8) Litters of 3-8 young born in May.
9) Young emerge in June at 4-6 weeks of age.
10) Young are independent by early July.
11) Surface activity may be bimodal in summer.
12) Plugging of burrows and hibernation occurs in mid-October.

Prairie Dog Survey Methods

1) Mark-Recapture – Provides the most accurate estimate of animal numbers, but is too labor and cost intensive.
2) Visual Surveys – Inaccurate – Social behavior and alarm calls result in animals entering burrows, and young may remain in burrows for hours.
3) Powell et al. (1994) developed a method for visual surveys.
    a) Park vehicle and wait 30 minutes.
    b) Count area twice and record the highest count.
    c) Repeat count every 20 minutes during 3 hour intervals.
4) Visual Counts under-estimate density (Fagerstone and Biggins 1986, Menkens et al. 1991)
5) Burrow Counts – Less costly and time-consuming than Visual Counts.

Prairie Dog Burrow Counts (Biggins et al. 1993)

1) Mark-Recapture – Provides the most accurate estimate of animal numbers, and was used to develop indices for burrow counts.
2) Total Burrow Count correlation to animal numbers is weak.
3) Active Burrow Count correlation to animal numbers is strong.
4) Colonies should be mapped prior to conducting survey.
5) Surveys should be conducted during mid-June to September, after young have emerged from burrows.
6) Survey transects across colony using a measuring wheel fitted with a 3m section of conduit.
7) Tally burrows as Active or Inactive based on scat presence.

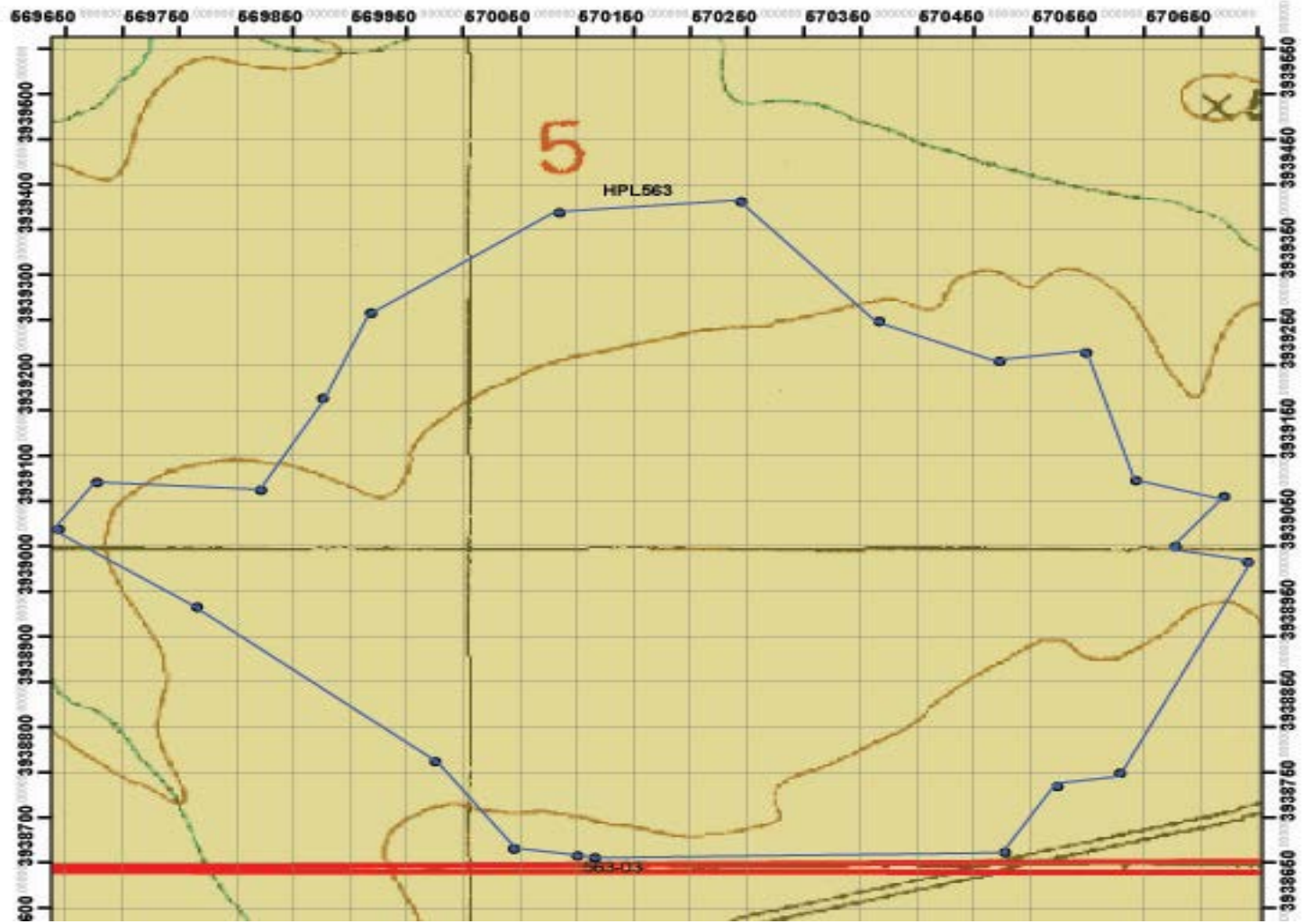
Key Elements of Active Burrow Counts

1) Count burrow if over half the opening is within the 3m transect area.
2) Count burrows with at least a 7cm diameter opening, and no visible end.
3) Count burrows dug-out by badgers, as PDs still use these.
4) Consider a burrow active if fresh PD scat is within 0.5m of opening.
   Fresh droppings are greenish-black or dark brown.
   Old scat is hard and bleached white.
5) Do not use digging, tracks, or PD sightings as criteria, due to lack of consistency between observers.
6) Select a direction across the colony and locate transects at equal intervals.
   For a 5% sample, using a 3m width, transects can be 60m apart.
7) Start at one end of the colony, walk the transect line, move over the designated interval, and walk the next transect line back, so you traverse the colony many times prior to reaching the opposite end.
8) Orientation of the transect line is determined by a compass heading, and identifying a distant landscape feature.
9) Do not let the distribution of burrows bias the direction of the transect line

Modifications to Active Burrow Counts

1) Mapping Colonies in ArcGIS.
    a) Identify colony locations using Aerial Photos or DOQQs.
    b) Field check locations as some may be ant mounds.
    c) Map colony perimeter by recording GPS locations while on an ATV.
    d) Put colony boundaries in ArcGIS.
    e) Lay a 50m interval grid over colony in ArcGIS to delineate start and end points of each transect line.
2) Enter the UTMs of start and end points of each transect line into a GPS.
3) Use the “Go To” function on GPS to adhere to the transect line.
4) Move to the next transect line using the “Go To” function, and repeat.
5) Carry an aluminum extension pole, marked or cut at 3m, rather than conduit.

Prairie Dog Colony Grid Map



Active Burrow Count Density Estimates

1) Density formulas based on Mark-Recapture data to arrive at the best estimate of prairie dog numbers in the colony (Biggins et al. 1993).
2) White-tailed PD Density = (0.073 x Active Burrow Density) / 0.495
3) Black-tailed PD Density = (0.179 x Active Burrow Density) / 0.566

Biggins et al. (1993) did not develop a density formula for Gunnison's PDs

Cully (1993), citing (Eskey and Hass 1940, Ecke and Johnson 1952, Clark et al. 1985, and Menkens and Anderson 1989 and 1991), stated that White-tailed PDs occur in much lower densities than Black-tailed or Gunnison's PDs, and that Gunnison's PD densities can approach that of Black-tailed PDs.

Based on this, we averaged the White-tailed and Black-tailed PD density indices of Biggins et al. (1993) to arrive at indices for a Gunnison's PD density formula.

4) Gunnison's PD Density = (0.126 x Active Burrow Density) / 0.5305

Questions

Aging Nestling Golden Eagles

Hatching to 1 Week of Age

Covered with Off-White Down

2 Weeks of Age Off-White Down

Replaced By Snow-White Down

3 Weeks of Age

Covered with Snow White Down

3.5 Weeks of Age

Flight Feathers Erupt From Sheaths

4 Weeks of Age

Primaries and Secondaries Emerge

4-4.5 Weeks of Age

Small feathers emerging on body

5 Weeks of Age

Contour Feathers Erupting on Wings

Males Grow Feathers Faster Than

Females to Remain Competitive

6 Weeks of Age – Head Still Downy

Body Covered With Contour Feathers

7 Weeks of Age

Dark Feathers Appear on Head

7.5 Weeks of Age

Down Line Along Center of Crown

8 Weeks of Age

Head is Mostly Dark Feathered

8 Weeks of Age

Head is Mostly Dark Feathered

9 Weeks of Age

Body and Head are Completely Dark

10 Weeks of Age

Normal Fledging Age

First Year

Typical Juvenile Plumage

Sunset Over Joshua Tree

Montaña De Las Aguilas, Mexico