Appendix 1. Geospatial and remote sensing methods.

Using Esri ArcGIS ToolBox (Esri 2011), we derived our topographic predictors from a composite of 10-m digital elevation models (DEMs) for each of the sites. Each 10-m cell represents elevation above sea level in meters. From the DEMs we processed various derivatives including aspect, degree slope, and curvature. Aspect is calculated in a 3 x 3 window for each cell using its neighbors to identify the maximum rate of change in the downslope direction, then converted to compass direction. Resulting values ranged from 0 to 360 and were converted to an index of the aspect using the cosine of aspect. Values closer to 1 were northerly and those nearer -1 were southerly. Degree slope is a measure of the steepness of a slope from 0 to 90 degrees calculated as the maximum change in elevation from each cell using a 3 x 3 window. Curvature is essentially the slope intended to model topographic features; e.g., bowl-shaped features within foothills. This variable was included in an attempt to capture the topographic variety in the set of colonies where we studied Pinyon Jays.

Solar radiation determines micro-environmental factors on the Earth's surface. Because Pinyon Jays typically nest when temperatures can be quite cold, solar radiation may be an important factor in determining nest sites (Marzluff 1988, Marzluff and Balda 1992). We used the ArcGIS Solar Radiation tool set (Esri 2011) to create solar radiation surface models from 1 March – 15 April, when Pinyon Jays typically choose colony sites. For validation, we used a gridded data set of ground-based solar radiation values compiled by the State University of New York Albany (SUNY), available as part of the National Solar Radiation Database (2007). To generate a solar radiation surface over the extent of our study areas, we compared point solar radiation values calculated for our study areas by the tool to solar radiation values measured at a SUNY collection site central to each study area. The solar radiation model accounts for site latitude and elevation, surface orientation, shadows cast by surrounding topography, daily and seasonal shifts in solar angle, and atmospheric attenuation. To make the model representative of the designated time period, we parameterized the components of atmospheric attenuation (transmissivity and diffuse proportion) by testing different combinations and comparing our modeled point results to the measured solar radiation value based on the SUNY ground-based data. The best combination of transmissivity and diffuse proportion values resulted in only a 2% difference from the measured SUNY data. We then used the validated atmospheric variables and our 10-m DEM to create a continuous solar radiation surface for both study sites.

Pinyon Jays nest in larger trees with relatively higher canopy cover above and around the nest. Further, at the colony scale, jays abandoned colony sites with lower tree vigor, a measure of foliage thickness/greenness, and moved to areas with higher vigor (Johnson et al. 2014). To capture foliage greenness, we created Normalized Difference Vegetation Indices (NDVIs) for the study areas from Landsat 5 data acquired in 2005. January, July, and October scenes were acquired to maximize information on seasonal changes and differentiate structural and compositional elements in vegetation cover.

Prior to developing the indices, we exoatmospherically and radiometrically corrected the Landsat multispectral reflective bands 1-5 and 7, following Chander et al. (2009). These correction procedures account for inconsistencies due to changes in sensor calibration and differences in illumination. The index (Eqn. 1.1) emphasizes relative plant vigor by taking advantage of the near infrared (NIR) reflected response of green leaf concentration against the visible red radiation (Red) response which is absorbed by green vegetation:

$$\text{Eqn. 1.1: NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red})$$

Radiometric calibration (Eqn. 1.2) converts the 8-bit digital numbers (Q_{cal}) representing brightness values between 0 and 255 to radiance values ($L\mu$), while accounting for the variations in gains ($G_{rescale}$) and biases ($B_{rescale}$) of individual sensors due to sensor degradation:

$$\text{Eqn. 1.2: } L\mu = (Q_{cal} \bullet G_{rescale}) - B_{rescale}$$

The exoatmospheric correction (Eqn. 1.3) applied to the individual pixels for each band accounts for the seasonal differences of the Earth-Sun distance (*d*), solar elevation angle (Θ), and band-width variations in solar irradiance ($ESUN\mu$). Outputs from the model are surface reflectance values (ρ):

$$\text{Eqn. 1.3: } \rho = L\mu \bullet \pi \bullet d^2 / ESUN\mu \bullet \cos \Theta$$

We developed a “deciduous greenness” index by subtracting the January NDVI, when vegetation was senescent, from the October NDVI (approximating maximum “green-up”) to determine if other vegetation such as grasses and shrubs within the juniper savanna and woodland were important in colony site selection. We resampled the Landsat data from 30 m to 10 m to match the other digital datasets.

With ERDAS Imagine Spatial Modeler (ERDAS 2011), we created vegetation indices. The normalized difference senescent vegetation index (NDSVI, Eqn.1. 4) enhances the spectral characteristics of senescent vegetation, specifically grasses, which have a relatively low reflectance response in the red wavelengths (Red, Band 3) and a high reflectance in the mid-infrared wavelengths (MIR7, Band 7). The moisture index (Eqn. 1.5) compares relatively high reflectance values in the shorter wavelengths of the mid-infrared (MIR5, Band 5) against strong absorption at the longer wavelengths of the mid-infrared (MIR7, Band 7) caused by water molecules found in soil and vegetation.

$$\text{Eqn. 1.4: NDSVI} = (\text{MIR7} - \text{Red}) / (\text{MIR7} + \text{Red})$$

$$\text{Eqn. 1.5: Moisture Index} = (\text{MIR5} - \text{MIR7}) / (\text{MIR5} + \text{MIR7})$$

We compiled all layers into a single image and re-sampled to 10-m spatial resolution. The image file contained 15 layers available for the classification process.

Table A1.1. Raster stack of GIS data.

Raster Stack Order	Raster	Brief Description
1	cosine of aspect	Derivative of the DEM identifies the direction of slope calculated in radians (Esri function). Cosine of the aspect transforms the aspect into values ranging from -1 (due south) to 1 (due north).
2	digital elevation model (DEM)	Elevation in meters
3	Landsat 5 ETM July NDVI	Normalized Difference Vegetation Index for July 2005
4	Landsat 5 ETM July SVI	Senescent Vegetation Index for July 2005
5	Landsat 5 ETM July moisture index	Moisture Index for July 2005
6	Landsat 5 ETM January† NDVI	Normalized Difference Vegetation Index for January 2005
7	Landsat 5 ETM January† SVI	Senescent Vegetation Index for January 2005
8	Landsat 5 ETM January† moisture index	Moisture Index for January 2005
9	Landsat 5 ETM October NDVI	Normalized Difference Vegetation Index for October 2005
10	Landsat 5 ETM October SVI	Senescent Vegetation Index for October 2005
11	Landsat 5 ETM October moisture index	Moisture Index for October 2005
12	planiform curvature	Derivative of DEM, rate of change in the landscape, perpendicular to the slope
13	profile curvature	Derivative of DEM, rate of change in the landscape, in the direction of the slope
14	slope degrees	Value of the slope represented in degrees in the steepest direction
15	solar insolation	Solar Radiation Model includes direct and diffuse radiation and shadows from topography (Esri Tool)
16	curvature (WSMR only)	Derivative of DEM surface, the slope-of-the-slope

†WSMR Landsat dates were acquired in March 2005