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SIMULTANEOUS DOUBLE COUNT AERIAL SURVEY FOR ESTIMATING HORSE POPULATION SIZE WITHIN THE LOWER SALT RIVER AREA, ARIZONA.

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Introduction

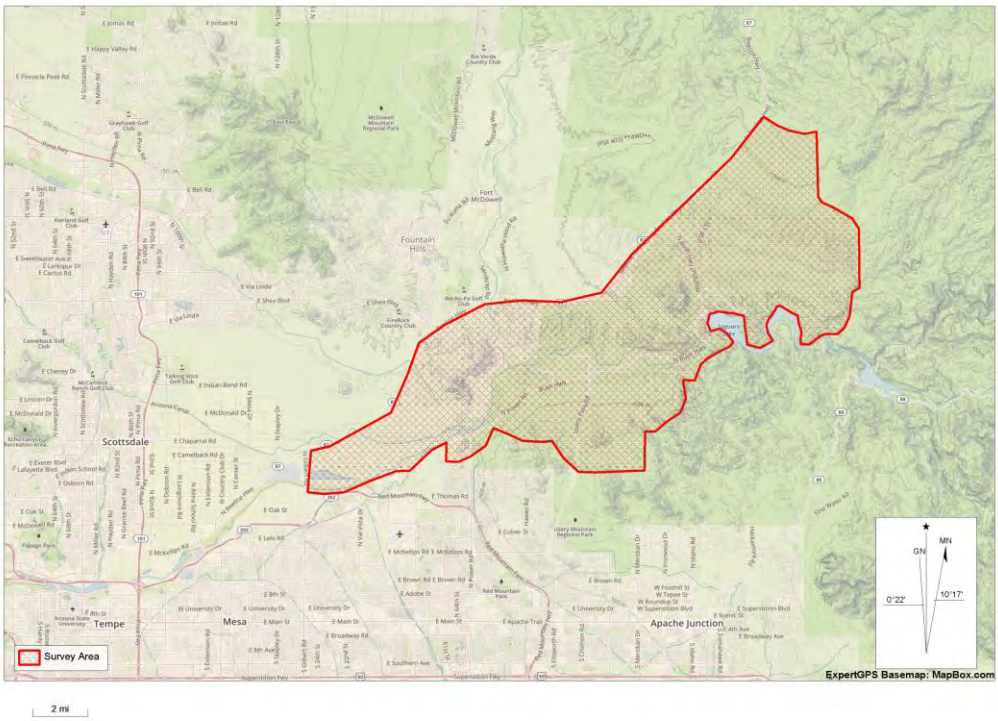
On March 29-30, 2017, the United States Department of Agriculture – Forest Service (Tonto National Forest), in cooperation with Arizona Game and Fish Department (AGFD), and the Arizona Department of Agriculture (ADA) conducted an aerial survey to estimate the size of the horse population within the Lower Salt River area. The survey used the simultaneous double count (double observer) method (Magnusson et al. 1978, Graham and Bell 1989, Forsyth and Hickling 1997, Suryawanshi et al. 2012), a technique previously adopted by AGFD for surveys of big game species, and later adopted by the Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS) for estimation of burros (Griffin 2014, 2015).

Description of Survey Area

The Lower Salt River is located in central Arizona, northeast of the Phoenix metropolitan area (Map 1). Land ownership within the survey area consists of Tonto National Forest, Fort McDowell Yavapai Nation, and the Salt River Pima-Maricopa Indian Community.

The survey area encompassed approximately 102 square miles. Cottonwood Creek and the edge of the Four Peaks Wilderness were used as the eastern boundary of the survey area. Forest Road #401, #143, and Highway 87 were used as the northern boundary of the survey area. Highway 87 and Gilbert Road were used as the western boundary of the survey area. Highway 202, the Salt River Pima-Maricopa Indian Community boundary, Tonto National Forest boundary, and Saguaro Lake were used as the southern boundary of the survey area. Major physical features of the survey area included the Lower Salt River Recreation Area, Saguaro Lake, Lower Verde River, Red Mountain, Stewart Mountain, and the Rolls Off Highway Vehicle Area. Topography of the area included river bottoms, rolling uplands, foothills, and mountains. Elevations ranged from approximately 1250 ft. at the western portion of the survey area to over 2900 ft. near the top of Stewart Mountain. The majority of the area was administered by the Tonto National Forest, with the remaining areas belonging to the Fort McDowell Yavapai Nation and the Salt River Pima-Maricopa Indian Community. The area provides habitat for a wide variety of resident and migratory wildlife species as well as diverse recreational opportunities.

Map 1. Survey area.



2017 Lower Salt River Horse Survey

There were three primary vegetation types within the survey area. The first, found on the bajadas on the western end of the survey area on the Salt River Pima-Maricopa Indian Community, was composed of creosote bush with smaller amounts of littleleaf paloverde, white bursage, cactus, and annual grasses and forbs. The second vegetation type, made up primarily of littleleaf paloverde with smaller amounts of ocotillo, white ratany, white brittlebush, white bursage, flattop buckwheat, creosote bush, annual grasses and forbs, was found in coarser soilson the uplands on either side of the Salt River on Tonto National Forest lands. The third vegetative type was a desert riparian type covering the main flood plain of the Salt River. Major components of this vegetation type included mesquite, saltcedar, arrowweed, seepwillow, blue paloverde, Fremont cottonwood, and Gooddings willow. Within the three vegetation types, plant species composition varied with topography and other ecological factors. Annual precipitation for the area averages 10.24 inches as recorded by the Flood Control District of Maricopa County gauge at Saguaro Lake (FCDMC 2017).

Survey Methods

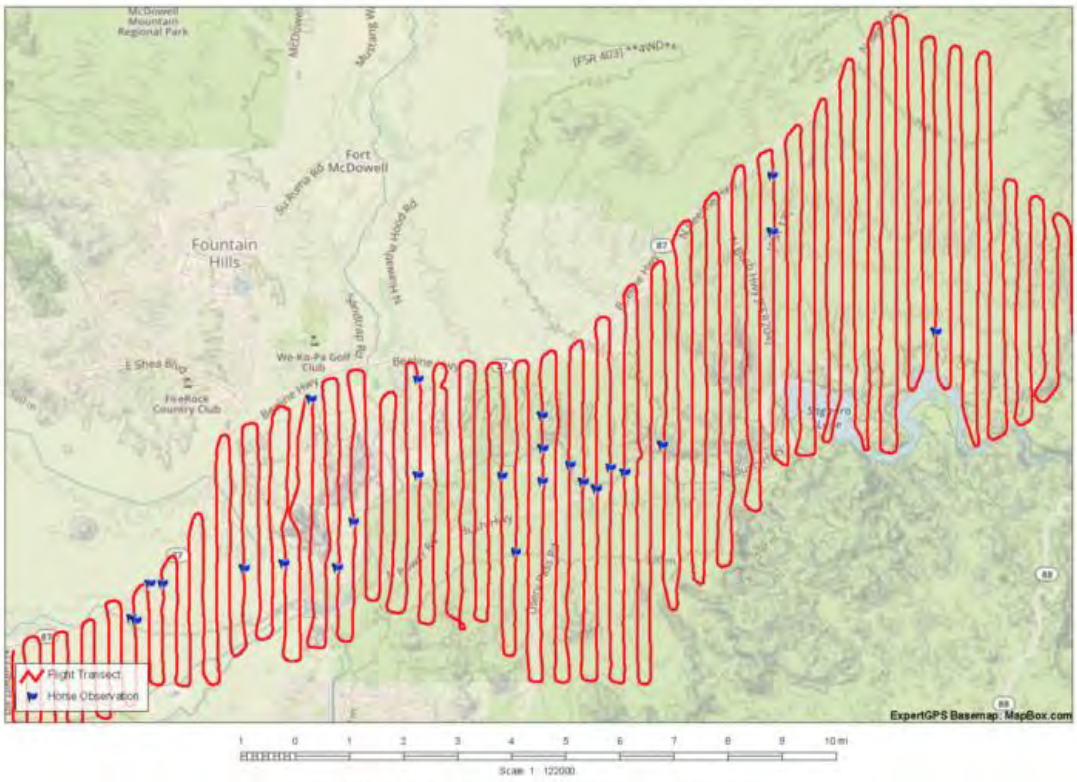
The BLM Standard Operating Procedures for aerial simultaneous double count survey was followed for this survey (Griffin 2014).

The survey area (Map 1) was developed cooperatively by the Tonto National Forest and AGFD based on known occupancy of horses at the time of the survey. Horses were also known to occupy areas to the north and west of Highway 87 on Tonto National Forest, Fort McDowell Yavapai Nation, and Salt River Pima-Maricopa Indian Community lands, but these areas were excluded. Having the survey area bounded by Highway 87 on the north and

west sides helped limit potential for horses to move into or out of the survey area between flights.

A Eurocopter AS350A (A-Star) helicopter carrying three observers, one data recorder, and the pilot was used to conduct the surveys. The helicopter maintained an altitude of approximately 200 feet above ground level and an average forward air speed between 50-60 knots (57-69 mph). The survey transects were flown in a North/South orientation at 0.25 minute longitude intervals (see Map 2), resulting in 100% coverage of the survey area.

Map 2. Survey transects and horse observations.



Survey flights were conducted during March 29-30, 2017. A total of seven hours and five minutes were used to survey 419 miles of transect lines. Transect width was 440 yards (220 yards on either side of the helicopter). The helicopter doors were removed to provide maximum visibility for observations within the transect areas. Weather conditions were considered very good for the survey period; no clouds, light winds, high contrast lighting, no precipitation, and temperatures between approximately 65 degrees Fahrenheit at the beginning of the survey and 75 degrees Fahrenheit at the end of the survey.

Survey flight track logs were recorded using a Garmin GPSmap 60CSx GPS unit and photographs were taken of most horse groups with a Canon EOS digital SLR camera with image-stabilizing zoom lens. Each flight path was documented by plotting onto an electronic topographical map using ExpertGPS. Waypoints were recorded for each independent group of horses that were observed and recorded on survey data sheets (Attachment 1). Only horses within the 220 yard sighting distance were recorded and any horse groups near the sighting distance limit were discussed among the flight crew to determine whether they were within or outside the existing transect. For horse groups observed outside the 220 yard sighting

distance, the flight crew did not record them at initial observation, but waited to see if they would be observed and recorded on the following transect. No horse groups were missed on the following transects.

One observer and the data recorder participated in both days of surveys, while the second and third observer was unique for each day. All observers were experienced and did not suffer from motion sickness. The pilot on the A-Star is located in the front left position. One observer occupied the left rear position during both days of survey effort. The data recorder occupied the rear middle seat for both days while the right rear observer operated the GPS and the right front observer operated the camera. Tandem observers on the right side of the helicopter were used to estimate the sighting probabilities for each observer position. Groups of horses observed solely by the pilot were not used to calculate sighting probabilities or population estimates nor were groups of horses observed while circling over other groups of horses. Individual horses were classified by age (≥ 1 year adult and < 1 year juvenile) when recorded.

Simultaneous double count protocols require tandem observers to make observations independent of one another. Consequently, it was essential that the tandem, right-side observers made observations without alerting the other observer when a group of horses was observed. Caution was exercised to avoid cueing the other observers with unusual head or body movements, thereby changing the likelihood of independently detecting the group of horses. Observed horses were only called out after the helicopter had passed by. This procedure gave both observers an equal chance to see the group. After either observer called out the sighting, the recorder determined if one or both tandem observers detected the group of horses.

Population Estimate Methods

There are two variations of determining population estimates based on the simultaneous double-count method, and they differ in terms of whether or not the left rear observations are used in generating the population estimate. We used each of these methods to generate a population estimate.

Technique 1

The first variation, based on Graham and Bell (1989), generates a correction factor (sighting probability) determined by the right side tandem observers' simultaneous double counting observations, and applies this to observations made by both rear-seat observers under the assumption that the left rear seat sighting probability is the same as that of the right rear seat.

N-hat Total, the population estimate for the entire surveyed area is defined as:

$$\text{N-hat Total} = ((S_2+S_3+B) * \bar{n}_{observed} * A)/P_2$$

Where:

S_1 = Number of groups seen only by the right front observer
S_2 = Number of groups seen only by right rear observer

S_3 = Number of groups seen only by left rear observer
B = Number of groups seen by both right observers
P_2 = Sighting probability of right rear observer = $B/(S_1+B)$
$\bar{n}_{observed}$ = Average group size of all groups observed during survey
A = Area correction factor. In this survey, because transects were spaced to allow 100% visual coverage of the survey area, A = 1.

With this technique, confidence intervals incorporate the estimated variance of P_2 only (Griffin 2015), and are defined as:

$$95\%\ CI\ (N\text{-}hat\ Total) = ((S_2+S_3+B) * \bar{n}_{observed} * A)/(P_2 \pm 1.96 * \sqrt{(Var(P_2))}$$

Where $Var(P_2) = P_2 * (1-P_2)/(S_1+B)$

Technique 2
The second technique uses the right side only to determine sighting probabilities and determines population estimates for the area surveyed by the right side of the helicopter and then follows the assumption that a similar density of horses exists in the left side transect area and expands right side estimate to the left side of the transects (Magnusson et al. 1978, Graham and Bell 1989, Forsyth and Hickling 1997, Suryawanshi et al. 2012).

N-hat, the estimated population in the area surveyed on the right side of the helicopter is defined as:

$$N\text{-}hat = (G\text{-}hat) * (\bar{n}_{observed})$$

and N-hat Total, the estimated population in the entire surveyed area is defined as:

N-hat Total = ((N-hat) * (total square miles of surveyed area))/square miles surveyed on the right side of the helicopter

where G-hat, the estimated number of groups in the surveyed (right) side is defined as:

$$G\text{-}hat = ((S_1+B+1) * (S_2 + B +1))/(B+1) - 1$$

and
S_1 = Number of groups seen only by the right front observer
S_2 = Number of groups seen only by right rear observer
B = Number of groups seen by both right observers.

The variance of the total population estimate is defined as:

$$\text{Var(N-hat Total)} = ((\text{G-hat})^2 * (\text{Var}(\bar{n}_{observed}) + (\bar{n}_{observed})^2 * (\text{Var(G-hat)} - \text{Var(G-hat)} * \text{Var}(\bar{n}_{observed})$$

where

$$\text{Var(G-hat)} = (S_1S_2(S_1+B+1)(S_1+B+1)/(B+1)^2(B+2)$$

and

$$\text{Var}(\bar{n}_{observed}) = \sum((X_i - X)^2/(n^2 - n)$$

Where $X_1, X_2, \ldots X_i$ are the group sizes observed in the survey.

The 95% confidence intervals of N-hat Total = (N-hat Total) ± (1.96 * √(Var(N-hat))

Results and Discussion

Twenty four groups of horses composed of 414 (374 adults, 40 juveniles) individual horses were observed; 303 horses were observed on Tonto National Forest lands, 35 horses were observed on Fort McDowell Yavapai Nation lands, and 76 horses were observed on Salt River Pima-Maricopa Indian Community lands (Table 1). Age classifications resulted in an annual reproductive rate of 10%. Average group size for all horse groups observed was approximately 17 horses with a density of 4.85 horses per square mile of area surveyed. Observers noted density was higher near water sources, particularly along the Lower Salt River. One horse group (group #8) was observed while circling over another group and another horse group (group #15) was observed by the pilot only; both of these horse groups were not included in the calculations because the observations were not according to protocol. Three horse groups (#14, 19, and 24) were observed by both sides of the helicopter, but were each ultimately assigned to one side of the transect, based on where the majority of the horses were located. Groups #14 and 19 were assigned to the left side and group #24 was assigned to the right side.

Wildlife observed included six mule deer, four herds of javelina, three bighorn sheep, four coyotes, and various other small mammals and birds.

Table 1. Land ownership, number of horses observed.

Land Ownership	Number of Horses Observed
Tonto National Forest	303
Fort McDowell Yavapai Nation	35
Salt River Pima-Maricopa Indian Community	76
Total	414

During this survey, the sighting probability on the right side of the helicopter was 100 percent, meaning that the seven groups of horses observed on the right side of the helicopter were independently observed by both the right front observer and the right rear observer. Although this result is not common, it can be explained by horses being large, highly visible animals that often form large groups.

Using Technique 1, which assumes the observation rates of the right and left rear observers are the same, and uses observations made by the left rear observer as well as those made from the right side of the helicopter, we estimated there were 393 horses within the survey area. Because the sighting probability of the rear observers (P_2) was 1.0, we could not generate 95% confidence intervals. Typically, we would not add animals observed outside of the survey protocol to this estimate because sighting probabilities would already have accounted (or corrected) for these "missed" animals, but because the sighting probability generated by the right side observations was 1.0 (100%), addition of these animals does not represent a duplication of these animals. Therefore, a total of 21 horses (16 observed outside of protocol (group #8) and 5 observed by the pilot only (group #15)) was added for an adjusted population estimate of 414 horses.

Using Technique 2, which only uses observations and sighting probabilities from the right side of the helicopter, and assumes the density of the horses is the same on both sides of the transect, we estimated there were 250.2 horses within the survey area with a 95% CI of 188.9 – 311.5. Again, adding the additional 21 horses to this estimate, we generated an adjusted population estimate of 271.2 horses.

We observed 414 horses total during the survey. This observation, together with the adjusted estimate of 414 horses generated with the application of Technique 1, suggests that this is best current estimate for this population. The lower estimate generated with the application of Technique 2 is likely a result of a smaller number of horse groups observed on the right side of the helicopter, and the overall estimate being based on the right side observations. This technique doesn't use observations made on the left side of the helicopter, and in a survey with relatively small sample sizes this can influence resulting estimates.

It should be noted that the simultaneous double count method only generates an estimate based on the animals that are available to be seen; therefore, the estimate is based only on the visible segment of the population. During the survey, there may have been a portion of the population not available to be observed. These horses may have been under canopy cover, behind hills or boulders, or directly beneath the helicopter, where none of the observers can see them. It is an assumption of the data collection technique, animals directly beneath the helicopter will run out from under the ship and be available for sighting. This is a sound assumption for most wildlife species, but not always the case with horses. Horses, in general, are less likely to run from the helicopter than most wildlife species; therefore, more apt to be missed when directly under the helicopter. Due to this assumption, we consider the estimate of 414 horses as a minimum population size for this population.

Recommendations

Use of simultaneous double counts to estimate horse population size for the Lower Salt River area should continue until a better alternative is available. Ideally, the horse population should be surveyed annually to strengthen confidence in observation rates and detect changes in the horse population. All occupied areas should be surveyed as a unit to avoid complications associated with estimating population size under non-closed conditions unless effective barriers separate horses from emigrating or immigrating from the survey area. If the horse population is reduced significantly, the use of this method to estimate population size will become more problematic. Typically, smaller populations may not provide large enough sampling to determine with any confidence the probability of detection (P_2); however, this is less of a problem when P_2 is high as it was in this survey. It may be possible to build a database using simultaneous double counts data over a series of surveys. This data could be used to interpret the results of a survey conducted on small populations. Survey timing should continue to be targeted towards late winter or early spring to maximize animal visibility. As the weather warms, dormant trees leaf-out, and animals tend to become less active during daylight and seek cover in heavily vegetated drainages, thereby negatively affecting sighting probabilities.

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