Peregrine Falcon Monitoring within Lake Mead National Recreation Area, 2008-2009

Final Project Report

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EXECUTIVE SUMMARY

- Peregrine falcons were monitored at Lake Mead National Recreation Area during the breeding seasons of 2008 and 2009.
- Several survey methods were used to locate breeding territories and eyries, evaluate occupancy, track breeding effort, and determine reproductive success.
- A call-broadcast approach was developed and used to efficiently evaluate territory occupancy and to locate new breeding territories.
- Call-broadcast was used with a habitat suitability model to rapidly assess 111 new sites for peregrines, resulting in the discovery of 6 previously unknown territories and verification of 4 additional unconfirmed territories.
- The number of known territories has continued to increase with search effort, and a total of 35 breeding territories have now been identified.
- In 2008, 25 breeding attempts were documented at 28 occupied territories and in 2009, 28 breeding attempts were documented at 32 occupied territories.
- The total number of successful young was estimated at 39 in 2008 and 55 in 2009.
- The minimum number of adults detected was 55 in 2008 and 61 in 2009.
- The number of breeding pairs is reaching very high concentrations in three areas of the park – Black Canyon, Boulder Canyon, and Virgin Canyon.

BACKGROUND

Peregrine falcons (*Falco peregrinus*) are primarily cliff-nesting raptors that prey mainly on other avian species. They are highly territorial, and show a high degree of mate and site fidelity between years (White et al. 2002, Ratcliffe 1993). Often the use of specific nesting cliffs can span generations, as individuals and pairs replace each other, with nearly continuous occupancy of a nesting area over decades or centuries (Newton 1979, Ratcliffe 1993). Although these falcons can employ several hunting techniques depending on the prey type and surrounding terrain, they tend to be most successful hunting from above and using speed and surprise to their advantage. For this reason, and to protect their eggs and nestlings from terrestrial predators, peregrines tend to breed in areas with high topographical relief preferably adjacent to open areas which affords their prey a low number of escape options.

Peregrines were listed as federally endangered under the Endangered Species Act in 1973 after suffering a dramatic decline over most of their North American range, primarily caused by exposure to the persistent pesticide DDT and other chlorinated hydrocarbons (White et al. 2002). The species has begun to recover following restrictions on DDT use, and was subsequently delisted by the U.S. Fish & Wildlife Service (USFWS) in 1999. As primary predators, peregrines remain vulnerable to persistent environmental contaminants, and localized populations have not always recovered successfully (Mora et al. 2002, Elliott et al. 2005). As part of a recovery strategy, continued monitoring to determine the stability of regional populations has been recommended through 2015 (USFWS 2003).

Peregrines were considered extirpated as a breeding species in Nevada from the 1950s through 1985 (Walton et al. 1988, Floyd et al. 2007), at which time a breeding pair was documented along the shoreline of Lake Mead within Lake Mead National Recreation Area (LMNRA). Since that time, efforts have been made to monitor peregrines within LMNRA and a sustained increase in the number of known nesting territories has been documented (Table 1). Currently, the steep cliffs adjacent to the shorelines of lakes Mead and Mohave within LMNRA contain the core breeding population of peregrine falcons in Nevada, and contribute substantially to a broader distribution of breeding peregrines in Arizona. Within the LMNRA region, 35 breeding territories have been identified with 32 of these sites occupied in 2009 (Fig. 1).

The National Park Service (NPS) has actively supported monitoring of peregrines within LMNRA, with actual monitoring conducted by various personnel associated with the NPS, Nevada Department of Wildlife (NDOW), Arizona Game and Fish Department (AGFD), and more recently by the Public Lands Institute, University of Nevada, Las Vegas (UNLV). Monitoring approaches, intensity, and objectives have varied widely over the years, but surveys mostly have focused on determining occupancy at known breeding territories with much less effort focused on searching for additional breeding areas. In 1990 and 1991 a more intensive effort by Glinski and Garrison (1992) was focused on Black Canyon, predominately along the stretch of the Colorado River below Hoover Dam. Over a two year study, these researchers attempted to locate all peregrine falcon breeding territories in the canyon, identify important foraging habitats along the canyon and adjoining landscape, and document the presence/absence of peregrines during the nonbreeding season. They documented occupied eyries roughly every 5 river km within Black Canyon, which was consistent with previously documented densities of breeding peregrines in other favorable habitats (Brown et al. 1992, Ratcliffe 1993). Monitoring efforts since 2006 have been conducted largely by UNLV personnel and focused on determining a more accurate estimate of the number of active territories within the park, and on monitoring yearly occupancy and reproductive effort at all known breeding territories (see Barnes 2006). This level of effort was made possible with funding contributions to the NPS from the Clark County Multiple Species Habitat Conservation Plan (MSHCP).

PROJECT GOALS AND OBJECTIVES

The information contained herein represents the final report for work conducted by NPS on peregrine falcons during 2008 and 2009 with funding from the MSHCP (Contract reference: 2005-NPS-475-P). In addition, results from previous monitoring efforts, specifically the previous MSHCP funded project in 2004 and 2005 (Contract reference: 2003-NPS-229-P-2004-07) are referenced in

this document. The survey efforts during these periods have utilized several survey methods to locate peregrine breeding territories, evaluate habitat quality, track breeding effort, and determine reproductive success. The array of approaches results from the need to meet project objectives in the face of an expanding number of indentified territories, as well as following established protocols and historical approaches used in the park. Significantly, a new survey protocol was developed by UNLV personnel (i.e., call-broadcast) during the 2008 and 2009 breeding seasons. The multi-approach monitoring strategy, as described herein, falls within the minimum post-delisting protocols for peregrines as outlined by the USFWS (2003). That plan calls for three monitoring surveys to be conducted of a selected subset of territories during the breeding season (April–July) each year to determine presence of adult birds and document reproduction, specifically the documentation of nestlings or fledglings.

METHODS

Survey and Monitoring Methods

Following are descriptions of each survey method used and the primary objectives, as employed by UNLV and NPS personnel over the last several years, with emphasis on the current project survey period.

Active Surveys – The flying of domestic pigeons (*Columba livia*) near eyries to elicit responses from potential resident peregrines has been the primary method employed by NPS personnel at LMNRA from 1985-2007. These 'active surveys' were conducted by boat with at least two trained observers, and were generally conducted at least once per breeding season (usually April through June) at all known peregrine territories. To minimize double counting, active surveys of all territories and other potential sites along each lake were completed during the same day, beginning as soon as possible after sunrise so as to survey falcons during their most active time of the day. Annually the number of sites monitored increased as new territories were discovered. The primary objectives of the active surveys were to establish presence of territorial peregrines and determine their breeding status. Eyrie locations and presence of young were noted when observed, but these were not primary objectives. These active surveys generally lasted around 30 minutes at each site, but varied according to peregrine presence and behavior at the time of the survey. The use of pigeons began to be phased out in 2006 in favor of more standardized survey methodology and alternatives (see Barnes 2006).

Passive Surveys – Within the last several years, a standard survey protocol was implemented that followed USFWS (2003) guidelines. This method consists of spot surveys conducted throughout the breeding season to determine occupancy, breeding attempts, and reproductive success (Glinski et al. 1993; Barnes 2006). Passive surveys were first implemented at LMNRA in 2006 at selected sites, as called for by the USFWS (2003) post de-listing monitoring plan. In coordination with state resource managers, three territories in Nevada and eight territories in Arizona were initially selected as part of each state's random sub-sample of known breeding territories. These sites were scheduled to be monitored once every three years through 2015. In 2007, and subsequently in 2008 and 2009, the number of passively surveyed sites within LMNRA was expanded to include all known territories

within the park. In addition, this method was used at promising sites in 2007 and 2008 in an attempt to discover previously undocumented peregrine territories.

Following the national protocol, the passive surveys consisted of up to one four hour monitoring session at each selected territory during peak diurnal activity periods; observations employed 10 X 50 binoculars and 20-60 power spotting scopes. Depending on the breeding stage, the observer did not remain at the site the entire four hour period if the desired information was obtained quickly. These passive surveys were conducted as needed to determine occupancy, breeding attempts, and breeding results throughout the courtship and breeding season (March–July in 2006; February–July after 2006). After initial observations, it was determined that surveys could be conducted throughout all daylight hours early in the season and then gradually shifted to focus on early morning and late afternoon periods by mid-May as temperatures rose and peregrine activity levels declined. When conducted in the evening, surveys could be continued the next morning after first light if needed.

During each of the passive surveys, the observer recorded the coordinates of the observation point, the temperature, approximate wind speed, percent cloud cover, and time of the effective survey period. When applicable, the observer recorded the nesting cliff coordinates, estimated distance to the nest cliff from the observation point, the bearing to the nesting location, and the aspect of the eyrie. An attempt was made to record the number of individuals, age, and sex of all peregrines encountered during the survey period (see Appendix 1 for example of field data form). Aging the young was done by visually comparing nestlings to a standard photographic guide (Cade et al. 1996). Detailed behavior and general observation notes were taken, as well as documentation of any observations of potential interspecific competitors (e.g., diurnal raptors, owls, ravens, turkey vultures, etc.).

Nonbreeding Season Site Occupancy – From August, 2008 through January, 2009, five territories were selected as a subset of the known breeding territories within LMNRA for monthly passive surveys in an effort to gain insight into whether peregrines observed during fall and winter months are likely local residents or migrants from elsewhere. The monthly surveys were initiated shortly after sunrise and followed the same passive methodology as described above, but used a shortened, two hour survey period centered on eyrie locations from the 2008 breeding season. Special attention was devoted to determining whether territorial behavior, or behavior that would indicate the presence of a pair-bond between resident adults (i.e., territorial display or defense, cooperative hunting, prey sharing, or affinity for the nesting area) was exhibited which might indicate whether the observed birds were local breeders remaining on site or rather were nonresidents which may have migrated or dispersed from other breeding areas. It was necessary to rely on behavioral cues to determine residency because no peregrines have been marked in this region since Glinski and Garrison's (1992) limited effort in the early 1990s, and it is extremely difficult to visually determine the identity of unmarked peregrines in the field.

Call-broadcast Surveys – In conjunction with this project, UNLV researchers developed a call-broadcast survey technique in 2008 in order to reduce the time necessary to establish presence of territorial peregrines from that required using the passive method, as well as eliminating the need to conduct active surveys using live pigeons. Call-broadcast surveys have been previously shown to be

an effective survey method for nocturnal species, cryptic species and species occurring in low densities (e.g., Johnson et al. 1981) and, in particular, for owls (Barnes and Belthoff 2008) and woodland raptors (Mosher et al. 1990, Roberson et al. 2005). Research conducted within LMNRA during the 2008 and 2009 breeding seasons established the effective range and response rates and detection rates of peregrines to broadcasted conspecific calls throughout the breeding season. A detailed assessment and description of the call-broadcast approach is being written, but this is outside the scope of deliverables for this project and only a summary of the methods and results associated with monitoring are provided herein.

The call-broadcast surveys were primarily conducted during early morning (½ hour before sunrise to 4 hours after sunrise) and late afternoon (4 hours before sunset to ½ hour after sunset) when peregrines are known to be most active. The protocol consisted of a 10 min. survey session at each point. Each point survey began with a 3 min. passive listening and observation period. If no peregrines were detected, a 30 second broadcast period was played, followed by a 1 minute observation period, a second 30 second broadcast period, and a final 5 minute observation period. Broadcasted conspecific calls consisted of 5 seconds of the "cack" alarm call immediately followed by 10 seconds of the "creak" or "eechup" call from an adult female (White et al. 2002). Vocalizations from a commercially available recording (Stokes Field Guide to Bird Songs: Western Region; Time Warner Trade Publishing, New York, NY) were converted to mp3 format and downloaded directly to digital game caller (FoxPro XR6; FoxPro Inc., Lewiston, PA). The cycle was looped once for 30 seconds of continuous calling, with the observer rotating 360° during each 30 second broadcast period in order to evenly project the sound around the area. Call-broadcast surveys were not conducted during precipitation or when sustained wind speeds approached 16 km/hr or greater. Broadcasting was stopped immediately upon detection of a response (vocalization or flight) so as to minimize disturbance. The data recorded included: distance of the observer to the eyrie and any detected falcons, time to response, duration of response, type of response, intensity of response, as well as the sex, maturity and breeding stage of responding individuals (Appendix 2).

Rapid Assessment – As part of the effort to better identify potentially undocumented territories, researchers from UNLV developed a habitat suitability model (also known as a species distribution model) for peregrines within the LMNRA region. The modeling effort was conducted under an associated MSHCP project (Contract reference: 2005-NPS-609C-P) and described in a separate document. The preliminary model was generated using a maximum entropy approach in the program Maxent (Phillips et al. 2006) from all known eyrie locations through 2008 and was predominately based on slope and solar radiation (watt hours/m^2) values. This model was visualized in a Geographic Information System to generate useful field maps.

The preliminary model was used to target call-broadcast surveys in areas of the most promising habitat patches. Specific survey points were selected based on areas predicted as having high peregrine breeding habitat potential from the model or where previous incidental sightings of peregrines were observed (e.g., Fig. 2). The call-broadcast method was used to conduct a rapid assessment for peregrines at these points. Since peregrines are known to be highly territorial, the survey points were placed outside previously known territories (i.e., generally > 2 km from the nearest known eyrie or territory center; Fig. 3). Additional call-broadcast or passive surveys (as

needed) were repeated at all sites where peregrines were detected in order to determine territorial occupancy, breeding status, and to locate the eyrie if possible.

Occupancy and Reproductive Assessment

Site Occupancy – An occupied site was defined as an area containing at least one adult or subadult (2nd year plumage) territorial peregrine during a portion of the breeding season, regardless of whether evidence of a breeding attempt was observed. A peregrine territory was defined as an area that contains, or historically contained, one or more eyries within the home range of a mated pair (Steenhoff and Newton 2007). A territory will usually contain different eyries over succeeding years (sometimes on separate eyrie cliffs), and is an area where no more than one pair is known to have bred in the same year. An eyrie, as defined herein, consists of a peregrine nesting surface contained within, or on, a crack, hole, or ledge on the face of a cliff. Peregrines typically lay eggs directly on the substrate, not building a stick nest, but sometimes use old nests from other large bird species (e.g., red-tailed hawk, common raven, golden eagle). A nearest neighbor distance (NND) was derived for each territory as the distance in meters from one occupied eyrie or territory center, to the eyrie or territory center of the nearest neighboring territorial peregrines. In some cases the eyrie could not be located or a territorial adult, or pair, may persist at a site for a portion of the breeding period without laying eggs or selecting a nest. In those cases the observed territory center, which is the center of most activity observed throughout the course of the breeding season, was used to calculate distances.

Reproduction – A breeding attempt was designated for a territorial pair when copulation, prolonged courtship, or evidence of reproduction was observed (i.e., incubation posture, nestlings or fledglings present, adults delivering prey to the nest). Except where noted, only those breeding attempts detected by the observer in the early stages of the reproductive cycle (i.e., courtship or incubation) have been included when calculating breeding success rates and when determining numbers of young/breeding attempt. Laying and hatching dates were calculated indirectly after nestlings were observed. Age was determined visually using a photographic guide (Cade et al. 1996) and then backdated using the average number of days required for each stage of the breeding cycle (i.e., Laying = 7 days, Incubation = 31 days, Nestling = 42 days). Breeding success followed the USFWS (2003) definition in which a nest was considered to be successful if at least one nestling reached the age of 28 days old, otherwise stated as > 65% of their age at first flight (Steenhoff and Newton 2007). The apparent breeding success rate was calculated as the proportion of successful nesting pairs to the total number of known pairs in the population (Newton 1979, Steenhoff and Newton 2007). A breeding attempt was said to have been unsuccessful when a pair of adults previously observed engaged in prolonged courting or copulating did not produce eggs or produced infertile eggs, when nestlings were documented dead prior to attaining 28 days of age, or when the eyrie was verified empty by visual inspection prior to nestlings surviving to 28 days and no surviving young were discovered nearby. All known breeding attempts were monitored throughout the duration of each breeding season or until failure was confirmed.

Data Management and Restrictions

All data collected during surveys have been entered into a geodatabase. The accuracy and validation of all historical data prior to the current project has been verified by comparing all available hard copy field records and yearly site summaries with the digitized geodatabase records. Data collected throughout the course of this project was subjected to a quality accuracy assessment procedure wherein nearly 15% of all survey records were randomly checked for the accuracy of the electronic database with that of the field datasheets (108 of 732 records). The results of the quality assessment yielded an estimated 100% attribute accuracy rate for the 2008 and 2009 records. Annual results have been shared with NDOW and AGFD; which were responsible for forwarding the data to the appropriate USFWS regional office for the post de-listing monitoring assessment.

All location data and site descriptions contained in this report are considered both sensitive and confidential by the National Park Service and are to be withheld from public release pursuant to authority granted within section 207 of the National Parks Omnibus Management Act of 1998 (16 U.S.C. § 5937). Actual location data from this report cannot be presented on any mapping products, either electronic or printed, which are released to the public. This data cannot be transferred to any party outside of the federal government without the express written consent of the NPS.

RESULTS

Increased Survey Efforts

The steepest increase in number of known occupied territories at LMNRA has been recorded from 2006-2009, with 19 new territories recorded during this period (Tables 1 & 4). This corresponds with a greatly increased number of surveys per breeding season and, most importantly, a concerted effort to identify new territories with exploratory surveys. Of significance, the passive survey method was initiated in 2006, which placed researchers in the field for much longer amounts of time than in previous years and increased their chances of identifying active peregrine territories. The exploratory effort through 2008 mainly focused on shoreline areas accessible by boat that were identified by the researchers as potentially suitable for breeding peregrines, and utilized the active, passive, and call-broadcast survey methods. In 2009 call-broadcasting was used in conjunction with the preliminary habitat suitability model to high-grade potentially suitable areas in order to rapidly assess them for occupancy. This innovative approach allowed researchers to visit over five times the number of sites surveyed in previous years (111 in 2009 versus 21 in 2008). Importantly, the rapid assessment technique in 2009 was used to target many difficult to access areas away from water that previously had minimum attention (Figs. 2 & 3).

Territories and Breeding Success

Over the course of this study 53 individual eyries were identified at 30 different territories. In at least one territory the same eyrie was used in 4 consecutive years with successful breeding each year. At other territories peregrines often moved the eyrie location each year with variable success before and after the eyrie movement. Of the breeding attempts that were tracked in consecutive years

20 of 36 (55.6%) changed their eyrie location from one year to the next, with an average distance moved of about 149 m. The median distance between eyries in neighboring territories (NND) was 4,065 m in 2008 (mean 6,277, range 1,509-32,714 m) and 4,577 m in 2009 (mean 6,298, range 1,211-20,829 m) (Table 2).

The number of known peregrine territories within LMNRA increased from a single territory in 1985 to the current total of 35 in 2009 (Table 1). The most significant increase in known occupied territories was documented from 2006 through 2009, when the number more than doubled from 14 in 2005 (prior to initiation of current efforts) to 32 by the end of the current project in 2009. Much of this latter increase, however, may have resulted from increased efforts to identify previously undocumented territories. A total of 20 territories were surveyed all 4 years from 2006-2009. The average annual occupancy rate for these 20 sites was 85% with 17 of the territories occupied all 4 years and the other 3 sites occupied in 3 of the 4 years.

The survey effort in 2008 identified 25 active breeding attempts at 28 occupied territories (Tables 1 & 3). One site in 2008 was not discovered until late in the breeding season, while at the other three sites where breeding activity was not identified, nesting areas were not located and adult activity diminished or ceased over time. In 2009, 28 breeding attempts were documented at 32 occupied territories (Tables 1 & 3). At the nonbreeding sites, adult activity ceased prior to the verification of a breeding attempt at one territory while three territories were held by single, unpaired birds for lengthy portions of the breeding season. Interestingly, two of these latter territories were held by subadult (2nd year) birds which generally are not known to breed in stable populations (Ratcliffe 1993, White et al. 2002). In 2007, however, an adult male paired with a subadult (2nd year) female, but that breeding attempt was unsuccessful. In 2006, 15 breeding attempts were documented at 20 occupied territories (including 7 attempts located late in the season), while in 2007 only 12 of 25 occupied territories had documented breeding attempts (Table 2).

From 2006-2009, the average date of initial laying was March 15th, with an average of 40 days passing between the first and last laying pairs of each season. The overall breeding success rate for 2006-2009 was 70.8%, with yearly rates fluctuating from 66.7% to 75%, respectively (Table 3). The cumulative mean number of successful young/occupied territory was 1.15, and the mean number of successful young/breeding attempt was 1.68. From 2006-2009 the average number of young/successful breeding attempt was 2.37. The above calculations only use those territories discovered early in the breeding season (courtship and incubation) in order to minimize the influence of early breeding failures that would likely go undetected in territories found late in the season. In particular, overall estimates of breeding attempts and breeding success from 2006 are likely biased (towards higher values) because nearly 50% (7 of 15) of the breeding attempts for that year were not discovered until late in the breeding season. Overall yearly totals in the number of successful young documented within LMNRA increased from 21 and 22 in 2006-2007 to 39 and 55 in 2008-2009, respectively, which was largely a reflection of the increase in known breeding territories during this period.

Call-broadcast and Rapid Site Assessment

The call-broadcast technique was used extensively to successfully evaluate territory occupancy early in the season in 2008 and 2009, and as a component in attempts to rapidly assess

areas for undocumented territories in 2009. Rapid assessments for peregrines were conducted using call-broadcast at 111 individual locations, primarily from February 25 through April 13 (courtship through incubation) with some follow-up visits in late May (132 total call-broadcast events). These sites were identified as having a high likelihood of containing suitable breeding habitat based on the preliminary habitat suitability model that highlighted about 2% of the area of LMNRA. Peregrines were detected at 12 of the 111 rapid assessment survey points, resulting in the discovery of 6 previously unknown territories and verification of 4 additional territories that were suspected but previously unconfirmed; 2 of the positive detections were duplicate observations of birds from territories previously discovered at earlier rapid assessment points. In the case of one of the newly verified territories, the eyrie turned out to be nearly 2.8 km from the primary activity center that had been identified during 3 previous years of surveys and incidental sightings but never pinpointed because of the rugged terrain and a large amount of suitable habitat in the area.

Nonbreeding Season Site Occupancy

Assessments of peregrine activity during the nonbreeding season at five territories provide evidence that many, if not most, peregrines within this region do not migrate and maintain a high level of site fidelity. Four of 5 sites showed relatively consistent occupancy throughout the nonbreeding season, and peregrine pairs were often present at 3 of the 4 regularly occupied sites (Table 5). These birds appear to have been residents and not migrants as they showed a strong affinity for perching on the eyrie cliff (usually within 100 m of the eyrie). Cooperative hunting, food sharing, and demonstrations of territory advertisement or defense were often detected (Table 5). No detections were made at one of the sites (Grebe Bay) after the October survey until midway through February, at which time courtship activities commenced. These data were supplemented by 15 incidental observations of adult peregrines on territories during the same time period, and additionally by 12 incidental sightings on territories during nonbreeding periods in previous years.

DISCUSSION

Breeding Numbers and Density

In 2004, a more focused effort was initiated to search for additional (undocumented) peregrine territories (Table 4), with the result that there has been a steady increase in the number of known breeding territories each year from 2004 through 2009. Large increases in the number of known territories occurred from 2006-2008 as the passive survey method was used in conjunction with the regular active shoreline surveys. A very large increase occurred again in 2009 as the newly developed call-broadcast method was combined with a habitat suitability map to rapidly assess many areas of predicted high quality habitat in a short period of time (Figs. 2 & 3).

Whether the known territories documented in 2009 reflects the actual number of territories present at LMNRA is not clear since the total number has continued to increase with increased search effort (Table 1), thus potentially documenting territories that may have previously been occupied but overlooked. Nevertheless, it is clear that the number of breeding peregrines at LMNRA has increased substantially after the detection of the first breeding pair in 1985 and now represents an important

regional breeding area (Appendix 3). With the exception of the intense search effort along the length of Black Canyon the early 1990s (Glinski and Garrison 1992), the survey efforts of NPS, NDOW, and AGFD were historically focused on monitoring areas with known peregrine presence, and new territories were added opportunistically as they were detected. Given this scenario, it seems likely that the detection of territories (Table 1) would have lagged behind that of the true rate of expansion of the breeding population. Furthermore, the detection of territories was likely biased towards those areas already known to have breeding territories, especially in areas with high density (i.e., Black Canyon, Boulder Canyon, and Virgin Canyon) where survey crews spent most of their time travelling to and from monitored sites.

While the rate and timing of the expansion of the breeding population at LMNRA is difficult to determine with accuracy, there are indications that particular locations have increased markedly in recent years. Black Canyon was thoroughly surveyed by an experienced crew during the 1990 and 1991 breeding seasons and, after surveying 49 sites, only 4 active territories were documented along the 35 km of river channel – an average of 1 pair/8.75 river km with a mean NND of 8,010 m. The current survey effort has likely been of similar intensity and during the 2009 breeding season 7 occupied territories were documented along the same river stretch, resulting in an average of 1 pair/5.0 river km with a mean NND of 4,323 m. Additionally, breeding territories along the canyon appear to have expanded southward with two territories identified in a 6 km stretch of canyon south of the original study area; one discovered in 1995 and one in 2007. Thus, as of 2009, a total of 9 territories have been active along the 40.3 km stretch of canyon with about 1 pair/4.5 river km (mean NND 3,990 m), roughly twice the breeding density detected in 1991 (Fig. 4).

With the increasing density of breeding peregrines in the LMNRA region, it is interesting to compare the breeding performance of the highest density sites (NND $\leq$ 5,000 m) with those of the lowest density (NND > 5,000 m). During 2008 and 2009, at 34 high density sites, 31 breeding attempts produced 61 successful young (77.4% breeding success, 1.79 young/occupied territory, and 2.54 young/successful territory). In contrast at 26 low density sites, 22 breeding attempts produced 33 successful young (59.1% breeding success, 1.27 young/occupied territory, and 2.54 young/successful attempt). Three areas of the park have high concentrations of breeding territories – Black Canyon, Boulder Canyon, and the Virgin Canyon area. All three areas exhibit high topographical relief with close proximity to water and are geographically separated from each other by open basins surrounded by low sloping bajadas; modeling also indentified these areas as having large amounts of predicted suitable breeding habitat (data not shown). As indicated above, in 2009 Black Canyon had 9 occupied territories (mean NND 3,990 m; Fig. 4), Boulder Canyon had 4 territories along 7.8 km of river channel (mean NND 2,205 m), and the Virgin Canyon area had 4 occupied territories along 15.7 km in the (mean NND 2,639 m).

Indicative of the aggressive and territorial nature of peregrines, the mean NND across the LMNRA region has not changed drastically over the past four years (6,781 to 6,298 m), even as the number of known territories and overall density appear to have both increased by nearly 60% in the same period (Table 2). However, the minimum NND has dropped over 26% (1,640-1,211 m), which is a result of increased crowding in the high density, canyon portions of the lake systems. The relative regularity of territory spacing in the high density areas (e.g., Fig. 4) is mirrored at a larger scale (Fig. 1). Territorial spacing in this species can be seen as a repulsion or avoidance of one territory to the next, so half the distance between two territories can be considered the area of

influence of each territory and will generally be defended by the resident falcons (Ratcliffe 1993). The minimum and average NND can then inform as to the minimum territory requirements in a given area (e.g., Fig. 4).

There is some evidence, though inconclusive, that peregrine numbers at LMNRA may be reaching local carrying capacity, particularly within the canyon areas along the lake shores. If the number of available nest sites has become recently limited, it might be expected that the number of agonistic conspecific encounters near eyrie sites would have increased in recent years, particularly during the courtship stage when eyries are being selected. It is known that male and female peregrines will readily adopt eggs and young from recently displaced breeders as a means to join the breeding population in subsequent years (Newton 1979, Ratcliffe 1993, White el al. 2002). Indeed, the number of observed aggressive conspecific encounters was highest in March and April during incubation and early nestling stages, and notably, the number of interactions in 2008 and 2009 (n=14) was more than 3 times greater than the number observed in the previous two years (n=4).

It is also possible to speculate that the recent survey efforts have begun approaching the documentation of an accurate breeding number within LMNRA. Of the newly discovered territories in 2009 at least four had no obvious accumulations of white wash which suggested only recent occupancy of these sites; two of the other sites could not be readily assessed for white wash. Importantly, no successful young were produced from the four sites, and in general the breeding success rate for the nine newly discovered sites was quite low (28.6%). These observations fit with known patterns that show younger breeding peregrines in newly established territories have lower success rates than older breeders with more years of experience (Newton 1979, Ratcliffe 1993, White et al. 2002). As further evidence that these sites represent a recent and possibly ongoing population expansion, two of the new territories were held well into the breeding season by single two-year old subadults, while a third territory was held by a pair that failed to establish a nest.

Nonbreeding Season Occupancy

Globally, peregrines are known to be highly migratory after the breeding season, particularly from their higher latitude breeding grounds, although markedly less so in more temperate regions (Ratcliffe 1993, White et al. 2002). Within LMNRA, Glinski and Garrison (1992) obtained mixed results for territorial occupancy by four adults during two nonbreeding seasons (defined as September through February by the authors) in the early 1990s. Since 2004, presence of peregrines within LMNRA has been documented regularly outside of the breeding season, both incidentally and during a monthly inventory and monitoring project; however, apart from limited evidence from the previous research in the early 1990s, it was not known to what degree the resident breeding peregrines remain in the area after young have fledged. The results from the monitoring of territories during the nonbreeding season in this study showing regular occupancy at 4 of 5 sites and bonded pair behavior at 3 of the sites indicates that site fidelity may be high (Table 5) and that seasonal migration of adult birds is not likely the prevalent pattern.

Peregrine Falcon Occupancy of Lakes Mead and Mohave Shorelines

Peregrines are not restricted to cliff-nesting in the absence of terrestrial predators and in these cases have been known to nest freely on the ground or on otherwise gradual slopes (Newton 1979, Ratcliffe 1993, White et al. 2002). Restriction to nesting on cliffs to avoid predators thus limits spatial distribution, and may limit density and population size in areas where prey is found in sufficient abundance. In addition to predator avoidance, nesting on cliff faces, and in cracks and overhung ledges, has the added benefit of shading nesting birds and young for at least some portion of the day. This could be a critical factor for nesting success within the low elevation areas along the Colorado River Valley where warm temperatures in certain years can become extreme by late spring when nestlings are still present.

Prey acquisition is also important, and the importance of the immediate area surrounding the eyrie cliff cannot be overstated. When possible, peregrines will utilize perches and ledges on the eyrie cliff in order to restrict energy expenditure when seeking and chasing prey. Access to prey near the eyrie also lowers the energy expended on hunting, especially when returning to the eyrie with prey (Newton 1979, White et al. 2002). A prominent eyrie cliff and presence of surrounding cliffs allows resident peregrines to employ a sit-and-wait hunting method whereby they wait for prey to fly beneath them and use gravity and surprise to their best advantage. The proximity of the eyrie cliff to the permanent water of lakes Mead and Mohave provides wide open hunting areas with limited cover and escape options particularly for terrestrial, non-aquatic birds that cannot take refuge in water.

Historically, the relatively recent creation of lakes Mead and Mohave in the otherwise harsh and arid climatic extremes of the Mojave Desert has enhanced the area's value as a migratory route for both terrestrial and aquatic birds (Rosenberg et al. 1991, Spence 1998). Regionally these reservoirs have increased the abundance and diversity of potential prey species for peregrines, as well as concentrating many of these species along shorelines directly below large cliff faces. In particular, at least 94 species of shorebirds, waterfowl, and other open water birds, many of which are directly available to peregrines as prey, use these lakes some in large numbers. At least 29 species have been observed during peregrine prey attempts or as prey remains at eyries or plucking perches (Tables 6 & 7). During the course of the present monitoring project, 204 predatory attempts have been observed on at least 39 species or prey types, and 28 of the avian prey species are dependent on either aquatic or riparian habitat types (Table 6). Of 144 prey attempts where the prey item could be adequately identified, 68% were directed toward avian species dependent on aquatic or riparian habitat types. Similarly, 25 of 34 (74%) of observed prey remains were of species dependent on open water or riparian habitat (Table 7).

In keeping with theory (Newton 1979, Ratcliffe 1993), a large difference of reproductive success rates was observed within LMNRA during the study period when accounting for distance of the eyrie to the nearest shoreline. When breeding success was compared for eyries $\leq$ 750 m from the shoreline with those > 750 m away from shorelines (2008 and 2009 combined), the success rates were much higher for sites near lake shorelines. Breeding attempts were observed at 39 of the 46 near shoreline territories with an 82.1% breeding success rate. These near-shore sites produced a total of 85 successful young, with 2.18 young/breeding attempt and 2.66 young/successful breeding attempt. By contrast, 12 breeding attempts were documented at 14 territories far from shorelines. The breeding success rate was only 33%, and these pairs produced only 6 successful young for an average

of 0.5 young/breeding attempt and 1.5 young/successful breeding attempt during the two year period. This assessment, however, may be confounded by the fact that many of the sites located away from the shorelines were also those that may represent new pairs occupying newly established territories.

CONCLUSIONS AND RECOMMENDATIONS

The total number of known peregrine falcon territories at LMNRA has continued to increase in recent years, reaching a high of 35 identified territories in 2009. The increase in territories, however, coincides with increased search effort. Nevertheless, during the 2008 and 2009 breeding seasons, the minimum number of adults detected within LMNRA was 55 and 61, respectively, with the number of breeding pairs reaching very high concentrations in three areas of the park - Black Canyon, Boulder Canyon, and the Virgin Canyon area. Documented breeding attempts have increased along with territories. In 2008, there were 25 breeding attempts documented at 28 occupied territories, and in 2009 there were 28 breeding attempts documented at 32 occupied territories. The number of successful young was estimated at 39 and 55 in the respective years. These data indicate an expanding population of peregrine falcons within the park.

Future Monitoring

While peregrine falcons have been increasing in number, the habitat for this species may be negatively impacted in the future by losses from increased recreational activities within prime breeding areas and by changes in water quality caused by increased concentrations and mixtures of contaminates. The impact of these threats can be monitored by evaluations of population trend and reproductive success rates. It is recommended that a long-term monitoring strategy be developed that will meet USFWS recommendations and NPS reporting requirements while minimizing effort. The strategy should adopt the recently developed rapid assessment call-broadcast technique to efficiently determine annual occupancy of a large subset of shoreline territories early in the breeding season. If conducted by a qualified and trained observer, such actions could take only a few days of concerted effort. Additionally, specific territories (and those selected by USFWS for long-term monitoring) should be assessed on a regular bias for reproductive success (USFWS recommendations are for every three years). To increase the power to detect local population trends, a subset of other known sites also should be assessed on a rotating basis.

Potential Banding Effort and Contaminant Testing

The high occupancy of territories from year to year, and an apparent ongoing increase in known breeding pairs, indicates the number of peregrines within LMNRA has not yet reached the carrying capacity of the local environment, although the data presented herein suggest that in certain habitats, density may be reaching a maximum. To further our understanding of the regional impact of the local peregrine population at LMNRA, a banding study should be conducted. Banding data would allow a better estimate of population size at LMNRA, provide estimates of juvenile and adult mortality rates, provide insight into site fidelity and territory turnover, and most importantly into regional dispersal patterns. Without knowing dispersal rates and movement patterns it is difficult to

truly assess local trends and to determine the impact that breeding birds at LMNRA have on the population of peregrines in the surrounding region. It can be speculated that the high quality sites on lakes Mead and Mohave are primarily responsible for the increase across LMNRA and possibly for the apparent increase of breeding activities in the much drier ranges throughout the rest of Clark County and the surrounding region (Christy Klinger pers. comm.), but very little is known for certain.

As an apex predator, peregrines remain vulnerable to bioaccumulation of persistent environmental contaminants and have been proven to be an indicator of contamination within regional ecosystems (Mora et al. 2002, Elliot et al. 2005). Lakes Mead and Mohave are downstream repositories for urban and industrial waste waters from the Las Vegas Valley, as well as residential, and agricultural areas along the Virgin and Muddy river drainages. The preys taken by peregrines at LMNRA are often aquatic or shoreline species that may absorb any number of the many potentially harmful compounds present in the aquatic system. Should a banding project be undertaken, it is recommended that biological samples (i.e., blood and feather samples) be taken from the birds for evaluation of biocontaminants. Such information may be useful for evaluating ecosystem health and emerging water quality issues (Henny and Elliot 2007) within the park.

Literature Cited

Anderson, D. E. (2007) Survey techniques. In: Bird, D. M., and K. L. Bildstein (eds.) Raptor research and management techniques. Hancock House Publishers, Blaine, WA, pp. 89-100.

Barnes, J. 2006. Report on peregrine falcon (*Falco peregrinus*) monitoring (2004-2005) within Lake Mead National Recreation Area. Unpublished report submitted to the Clark County Multiple Species Habitat Conservation Plan (MSHCP project no. 2003-NPS-229-P-2004-07) by the National Park Service, Lake Mead National Recreation Area, Boulder City, NV. 18 pp.

Barnes, K. P., and J. R. Belthoff. 2008. Probability of detection of flammulated owls using nocturnal broadcast surveys. Journal of Field Ornithology 79:321-328.

Brambilla, M., D. Rubolini, and F. Guidali. 2004. Rock climbing and raven *Corvus corax* occurrence depress breeding success of cliff-nesting peregrines *Falco peregrinus*. Ardeola 51:425-430.

Brambilla, M., D. Rubolini, and F. Guidali. 2005. Factors affecting breeding habitat selection in a cliff-nesting peregrine *Falco peregrinus* population. Journal of Ornithology 147:428-435.

Brown, B.T., G.S. Mills, R.L. Glinski, and S. W. Hoffman. 1992. Density of nesting peregrine falcons in Grand Canyon National Park, Arizona. Southwest Naturalist 37:188-193.

Cade T. J., J. H. Enderson, and J. Linthicum. 1996. Guide to management of peregrine falcons at the eyrie. The Peregrine Fund, Boise, ID.

Elliott, J. E., M. J. Miller, and L. K. Wilson. 2005. Assessing breeding potential of peregrine falcons based on chlorinated hydrocarbon concentrations in prey. Environmental Pollution 134:353-361.

Ellis, D. H. 1988. Distribution, productivity, and status of the peregrine falcon in Arizona. In: Cade T. J., J. H. Enderson, C. G. Thelander, and C. M. White (eds.) Peregrine falcon populations: their management and recovery. The Peregrine Fund, Boise, ID pp. 87-94.

Enderson, J. H., G. R. Craig, and W. A. Burnham. 1988. Status of peregrines in the Rocky Mountains and Colorado Plateau. In: Cade T. J., J. H. Enderson, C. G. Thelander, and C. M.

White (eds.) Peregrine falcon populations: their management and recovery. The Peregrine Fund, Boise, ID pp. 83-86.

Falk, K., and S. Moller. 1988. Status of the peregrine falcon in south Greenland: population density and reproduction. In: Cade, T. J., J. H. Enderson, C. G. Thelander, and C. M. White (eds.) Peregrine falcon populations: their management and recovery. The Peregrine Fund, Boise, ID pp. 37-43.

Gainzarain, J. A., R. Arambarri, and A. F. Rodriguez. 2000. Breeding density, habitat selection and reproductive rates of the Peregrine Falcon *Falco peregrinus* in Alava (northern Spain). Bird Study 47:225-231.

Glinski, R. L., and B. A. Garrison. 1992. Presence and movements of peregrine falcons in the area of the proposed Black Canyon bridge project. Unpublished Report. Arizona Game and Fish Department, Research Branch, Phoenix, AZ.

Glinski, R. L., T. J. Tibbitts, B. T. Brown, and S. Hoffman. 1993. Survey protocol for breeding peregrine falcons. Unpublished Report. Arizona Game and Fish Department, Research Branch, Phoenix, AZ.

Henny, C. J., and J. E. Elliot (2007) Toxicology. In: Bird, D. M., and K. L. Bildstein (eds.) Raptor research and management techniques. Hancock House Publishers, Blaine, WA, pp. 329-350.

Johnson, R. R., B. T. Brown, L. T. Haight, and J. M. Simpson. 1981. Playback recordings as a special avian censusing technique. Studies in Avian Biology 6:68-75.

Kochert, M. N. 1986. Inventory and monitoring of wildlife habitat. U.S. Department of Interior, Bureau of Land Management, Service Center, Denver, Colorado.

Mattox, W. G., and W. S. Seegar. 1988. The Greenland peregrine falcon survey, 1972-1985, with emphasis on recent population status. In: Cade, T. J., J. H. Enderson, C. G. Thelander, and C. M. White (eds.) Peregrine falcon populations: their management and recovery. The Peregrine Fund, Boise, ID pp. 27-36.

Mora, M., R. Skiles, B. McKinney, M. Paredes, D. Buckler, D. Papoulias, and D. Klein. 2002. Environmental contaminants in prey and tissues of the peregrine falcon in the Big Bend region, Texas, USA. Environmental Pollution 116:169-176.

Mosher, J. A., M. R. Fuller, and M. Kopeny. 1990. Surveying woodland raptors by broadcast of conspecific vocalizations. Journal of Field Ornithology 61:453-461.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD.

Phillips, S. J., R. P. Anderson, and R. E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modelling 190, 231–259.

Ratcliffe, D. A. 1962. Breeding density in the peregrine (*Falco peregrinus*) and raven (*Corvus corvax*). Ibis 104:13-39.

Ratcliffe, D. 1993. The peregrine falcon. 2nd ed. T & A D Poyser, London.

Roberson, A. M., D. E. Anderson, and P. L. Kennedy. 2005. Do breeding phase and detection distance influence the effective area surveyed for northern goshawk? Journal of Wildlife Management 69:1240-1250.

Rosenberg, K. V., R. D. Ohmart, W. C. Hunter, B. W. Anderson. 1991. Birds of the lower Colorado River valley. The University of Arizona Press, Tucson, Arizona.

Spence, J. R. 1998. 1994-1997 Lake Powell winter aquatic bird surveys, Glen Canyon National Recreation Area, Utah and Arizona. Unpublished Report. National Park Service, Resource Management Division, Page, Arizona.

Steenhof, K., and I. Newton (2007) Assessing nesting success and productivity. In: Bird, D. M., and K. L. Bildstein (eds.) Raptor research and management techniques. Hancock House Publishers, Blaine, WA, pp. 181-192.

U.S. Fish and Wildlife Service. 2003. Monitoring plan for the American peregrine falcon, a species recovered under the endangered species act. U.S. Fish and Wildlife Service, Divisions of Endangered Species and Migratory Birds and State Programs, Pacific Region, Portland, Oregon.

White, C. M., N. J. Clum, T. J. Cade, and W. G. Hunt. 2002. Peregrine falcon (*Falco peregrinus*). The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Laboratory of Ornithology.

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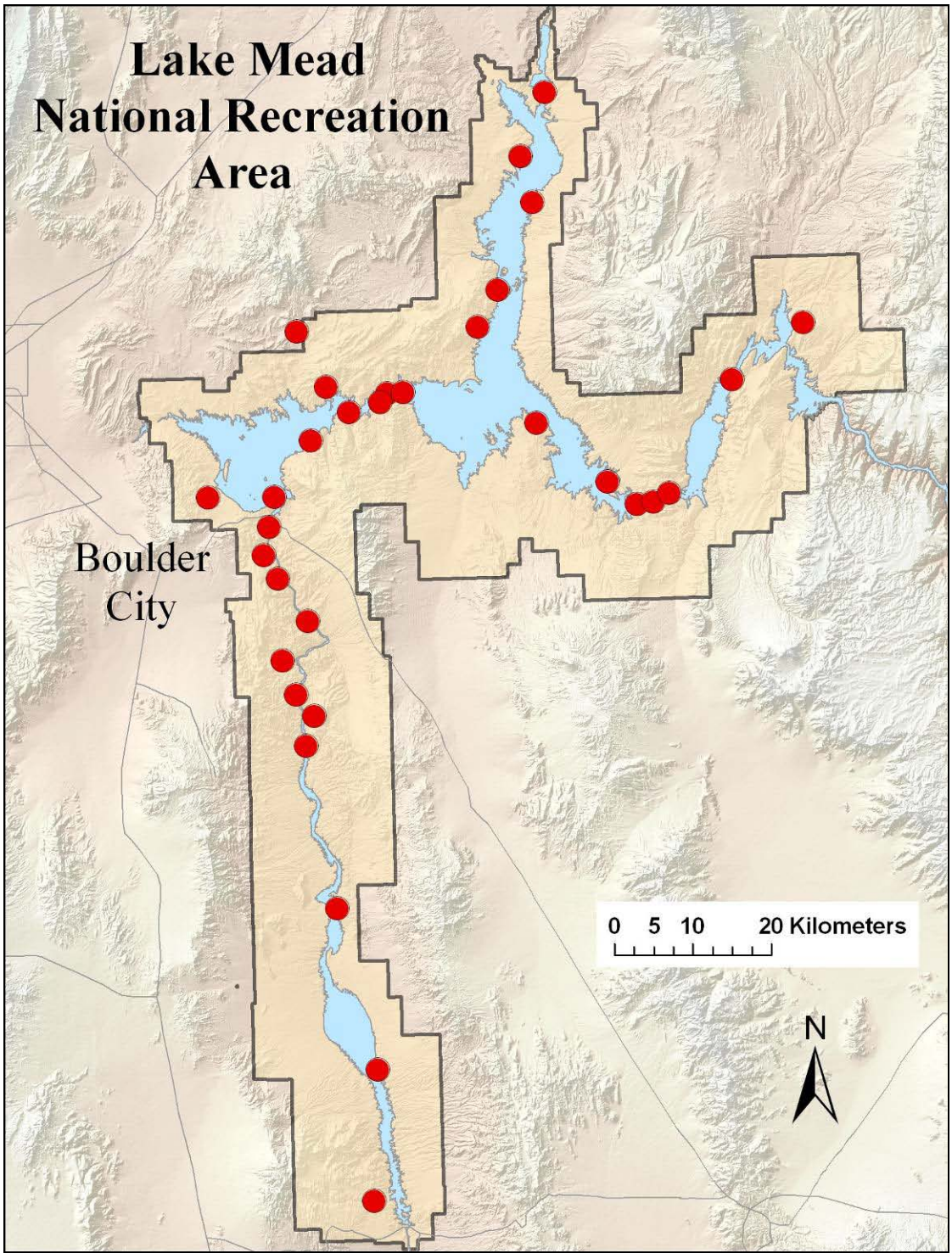

Figure 1. Occupied peregrine falcon territories (red dots) within Lake Mead National Recreation Area in 2009. An occupied territory was defined as a site containing ≥ 1 territorial peregrine present during a portion of the breeding season.

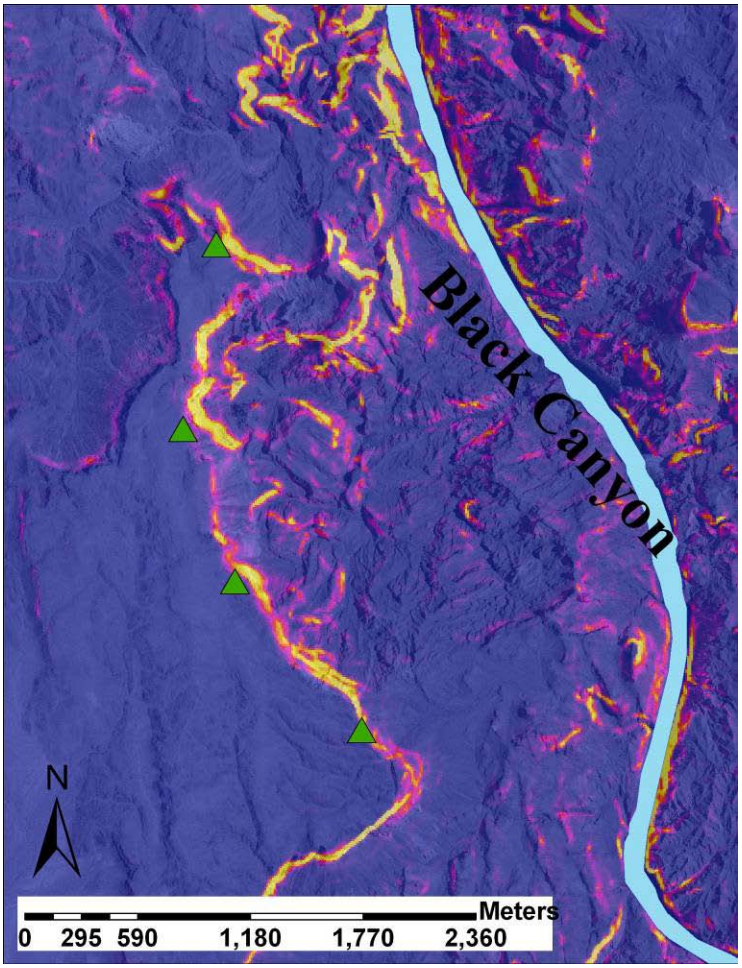

Figure 2. Example of rapid assessment survey locations based on a draft predictive habitat model in an area of Black Canyon, Lake Mead National Recreation Area. Call-broadcast survey points are indicated by green triangles. The draft predictive habitat model was generated using known eyrie locations prior to 2009 and was based predominately on slope and solar radiation variables. Red predicts areas of high suitability and yellow depicts areas of highest predicted suitability for breeding locations.

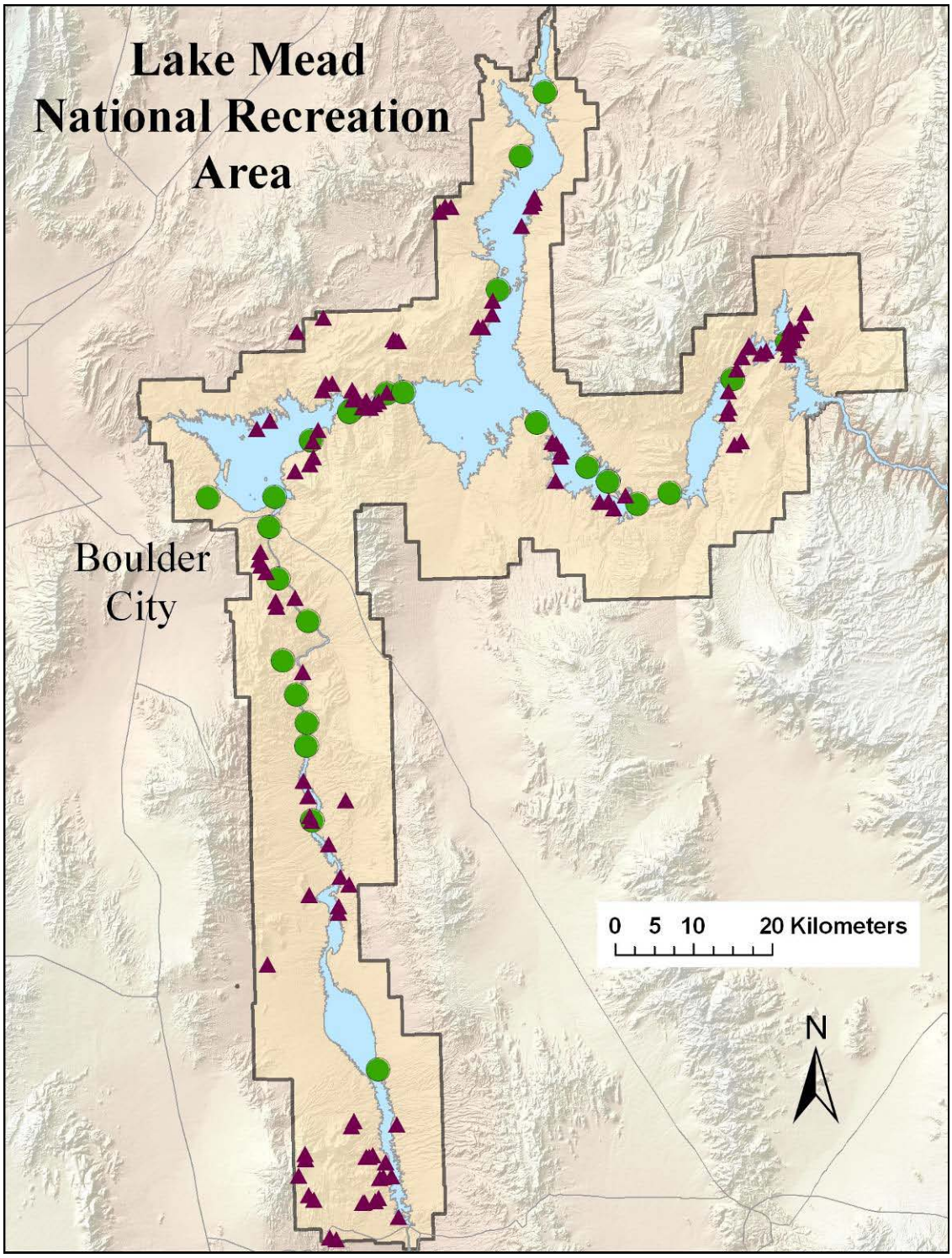

Figure 3. Occupied peregrine falcon territories in 2008 (green dots) and survey locations (purple triangles) for rapid exploratory assessments in early 2009 at Lake Mead National Recreation Area. An occupied territory was defined as a site containing ≥ 1 territorial peregrine present during a portion of the breeding season.

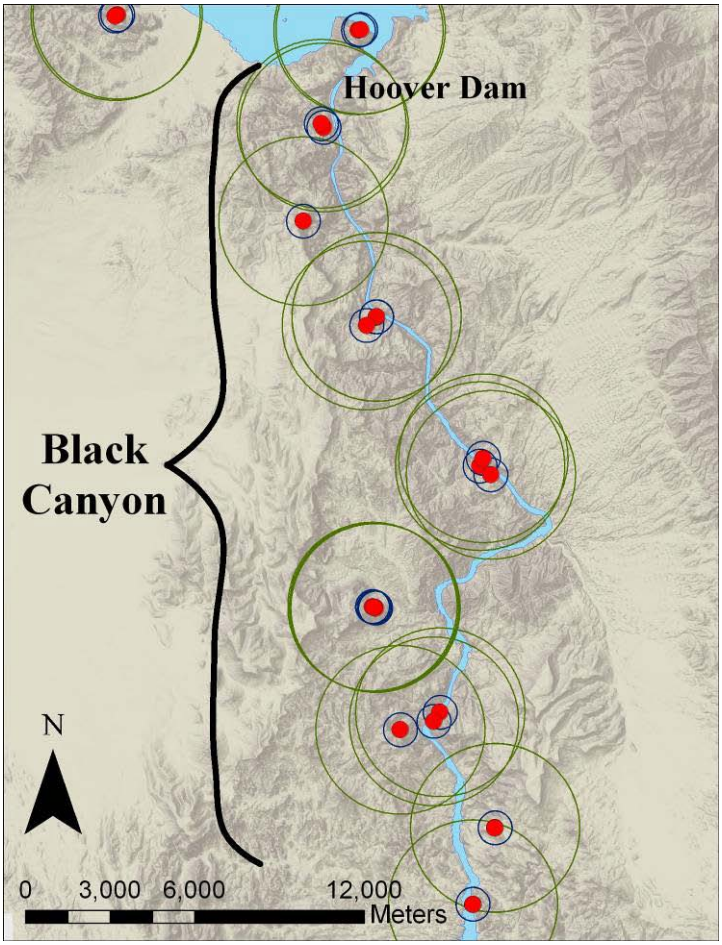

Figure 4. Distribution of known peregrine falcon territories in 2009 within Black Canyon, Lake Mead National Recreation Area (LMNRA). Red dots indicate eyrie locations at each territory, while tightly clustered dots depict alternate eyries used in different years within each territory. The blue circles around each eyrie are 600 m radius buffers, which corresponds to roughly half the minimum nearest neighbor distance (NND) between territories in 2009. The green circles around each eyrie represent 3,000 m radius buffers, which correspond to roughly half the mean NND of all known peregrine territories within LMNRA in 2009.

Table 1. Number of known occupied peregrine falcon territories within Lake Mead National Recreation Area from 1985 through 2009. An occupied territory was defined as a site containing ≥ 1 territorial peregrine present during a portion of the breeding season.

Date	Territories on or near Lake Mead	Territories on or near Lake Mohave	LMNRA Total Occupied Territories
1985§	1	0	1
1986§	1	0	2
1987§	1	0	1
1988§	1	2	3
1989§	1	3	4
1990*	1	3	4
1991*	1	3	4
1992	1	4	5
1993	1	5	6
1994	1	4	5
1995**	2	5	7
1996	3	5	8
1997	2	5	7
1998	4	4	8
1999	4	4	8
2000	5	4	9
2001	5	4	9
2002	5	3	8
2003+	7	6	13
2004+	7	7	14
2005+	9	5	14
2006	14	6	20
2007	16	9	25
2008	19	9	28
2009	21	11	32

§ Monitoring conducted exclusively by NDOW.
* Includes territories identified in AGFD research.
** Includes territories verified by AGFD.
+ Includes Burro Wash surveys conducted by NDOW.

Table 2. Summary of peregrine falcon territory density within Lake Mead National Recreation Area (LMNRA) during 2006-2009. An occupied territory was defined as a site containing ≥ 1 territorial peregrine present during a portion of the breeding season.

Category	2006	2007	2008	2009
Total occupied territories	20	25	28	32
Mean Nearest Neighbor Distance (m)	6,781	6,953	6,277	6,298
Median Nearest Neighbor Distance (m)	4,332	5,640	4,065	4,577
Minimum Nearest Neighbor Distance (m)	1,640	1,640	1,509	1,211
Density*	1 terr./188 km^2	1 terr./151 km^2	1 terr./134 km^2	1 terr./118 km^2

*This number represents known occupied territories per available land area in LMNRA (3,765 km^2). Unless all occupied territories were detected, the value does not account for the actual density of the entire breeding population of peregrines within LMNRA.

Table 3. Summary of peregrine falcon productivity at Lake Mead National Recreation Area from 2006-2009. An occupied territory was defined as a site containing ≥ 1 territorial peregrine present during a portion of the breeding season. A breeding attempt was designated for a territorial pair when copulation, prolonged courtship, or evidence of reproduction was observed (i.e., incubation posture, nestlings or fledglings present, adults delivering prey to the nest). Only those breeding attempts detected in the early stages of the reproductive cycle (i.e., courtship or incubation) have been included when calculating breeding success rates and when determining numbers of young/breeding attempt. A successful breeding pair was defined as having produced at least one offspring ≥ 28 days old, and a successful young was any nestling or fledgling ≥ 28 days old.

Categories	2006	2007	2008	2009	Total§
Occupied territories	20	25	28	32	105
Breeding attempts	15*	12	25**	28	72
Successful breeding pairs	13*	9	17**	20	51
Breeding success rate (%)	75.0	75.0	66.7	71.4	70.8
Successful young/occupied territory	1.05*	0.88	1.29	1.72	1.15
Successful young/breeding attempt	1.00	1.83	1.50	1.96	1.68
Successful young/successful breeding pair	1.62*	2.44	2.29**	2.75	2.37
Total successful young detected	21*	22	39**	55	121
Total adults detected	34	46	55	61	NA

§ Total calculations only include breeding attempts discovered early in the breeding season.
*Includes results from 7 breeding attempts discovered late in the breeding season, resulting in 13 successful young.
** Includes results from 1 breeding attempt discovered late in the breeding season with 3 fledglings.

Table 4. Summary of survey efforts for peregrine falcons within Lake Mead National Recreation Area throughout the 2004-2009 breeding seasons. Survey effort reflects surveys conducted by NPS and UNLV personnel only.

Categories	2004	2005	2006	2007	2008	2009
Total number of surveys	49	58	118	146	247	376
Total number of sites surveyed	15	25	30	39	49	139
Exploratory surveys	2	16	32	36	26	132
Number of exploratory sites	2	10	14	17	21	111
New territories discovered	1	1	5	4	4	6

Table 5. Summary of monthly survey results at five peregrine falcon territories at Lake Mead National Recreation Area during the 2008-2009 nonbreeding season (August–January).

Territory: 2008-09	August	September	October	November	December	January
Engine Beach	♂♀, TD, E, V	♂, E	U, PA*3	♂, PA, E, V	♀, E	♂, E
Grebe Bay	♂♀, CH, PA, E, V	♂♀, PA*3, E, V	♂, E	Unoccupied (2 surveys)	Unoccupied	Unoccupied
Promontory Point	♂, TD, E, V	U, E, V	♂♀, TD, E	♂♀, TD, E, V	♂♀, E, V	♂♀, C, CH*2, E
Chalk Cliffs	♂♀, CH, PA*2, E	♂♀, PA*2, E, V	♂♀, PA*2, FS, V, E	♂♀, CH*2, PA, E, V	♂♀, E, V	♂, PA*3, TD*2, E
South Basin Cove	♀, PA, E	Unoccupied	♂♀, CH*2, PA, E	♂♀, E	♂♀, E	♂♀, C, E

♂♀=pair; ♂=single male; ♀=singe female; U=unknown peregrine; C=courtship; TD=territorial display or defense; CH=cooperative hunting; PA=single adult prey attempt; FS=food sharing; E=perched ≤ 100 m from eyrie; V=vocalizing

Table 6. Observations of prey attempts by peregrine falcons within Lake Mead National Recreation Area from 2004-2009. Prey type was identified to the lowest possible taxa the observer could be certain of at the time of the observations.

Prey Type	Species	Total Attempts
Prey unidentified		1
Invertebrate unidentified		1
Bat unidentified		7
Bird unidentified		19
Aquatic bird unidentified		4
Eared Grebe	*Podiceps nigricollis*	11
Clark's/Western Grebe	*Aechmophorus spp.*	1
Double-crested Cormorant	*Phalacrocorax auritus*	3
White-faced Ibis	*Plagadis chihi*	1
Canada Goose	*Branta canadensis*	1
Duck unidentified	Anseriformes	1
Mallard	*Anas platyrhynchos*	2
Northern Shoveler	*Anas clypeata*	1
Cinnamon Teal	*Anas cyanoptera*	1
Green-winged Teal	*Anas crecca*	2
Ring-necked Duck	*Aythya collaris*	1
Red-breasted/Common Merganser	*Mergus spp.*	1
Ruddy Duck	*Oxyura jamaicensis*	1
American Coot	*Fulica americana*	15
Shorebird unidentified	Charidriidae, Scolopacidae	2
Killdeer	*Charadrius vociferus*	1
American Avocet	*Recurvirostra americana*	1
Spotted Sandpiper	*Actitis macularia*	1
Long-billed Curlew	*Numenius americanus*	1
Sandpiper unidentified	*Calidris spp.*	10
Sanderling	*Calidris alba*	1
Phalarope unidentified	*Phalaropus spp.*	1
Gull unidentified	*Larus spp.*	1
Ring-billed/California Gull	*Larus spp.*	1
Ring-billed Gull	*Larus delawarensis*	3
Tern unidentified	*Sterna spp.*	1
Dove unidentified	Columbidae	5
White-winged Dove	*Zenaida asiatica*	7
Mourning Dove	*Zenaida macroura*	4
Eurasian Collared-Dove	*Streptopelia decaocto*	4
Lesser Nighthawk	*Chordeiles acutipennis*	1
Belted Kingfisher	*Ceryle alcyon*	1
Passerine/land bird unidentified		45
White-throated Swift	*Aeronautes saxatalis*	1
Say's Phoebe	*Sayornis saya*	3
Swift/Swallow unidentified	Apodidae/Hirundinidae	2
Swallow unidentified	Hirundinidae	9
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	2
Wren unidentified	Troglodytidae	3

Rock Wren	*Salpinctes obsoletus*	1
Northern Mockingbird	*Mimus polyglottos*	1
Red-winged Blackbird	*Agelaius phoeniceus*	3
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	2
Great-tailed Grackle	*Quiscalus mexicanus*	11
House Finch	*Carpodacus mexicanus*	1
Total Prey Attempts		204

Table 7. Prey remains observed or collected from peregrine falcons within Lake Mead National Recreation Area from 2006-2009. Prey type was identified to the lowest possible taxa the observer could be certain of at the time of the observations. Observations were made by witnessing peregrines carrying, or feeding on, identifiable prey when the attempt itself was not observed, or collected either directly after peregrines finished feeding or from peregrine plucking perches when feeding was not observed.

Prey Type	Species	Total Individuals
Eared Grebe	*Podiceps nigricollis*	4
Double-crested Cormorant	*Phalacrocorax auritus*	1
Green-winged Teal	*Anas crecca*	1
Red-breasted/Common Merganser	*Mergus spp.*	1
American Coot	*Fulica americana*	7
American Avocet	*Recurvirostra americana*	1
Gull unidentified	*Larus spp.*	2
Ring-billed Gull	*Larus delawarensis*	3
Dove unidentified	Columbidae	2
White-winged Dove	*Zenaida asiatica*	2
Mourning Dove	*Zenaida macroura*	2
White-throated Swift	*Aeronautes saxatalis*	2
Swift/Swallow unidentified	Apodidae/Hirundinidae	1
Rock Wren	*Salpinctes obsoletus*	1
Canyon Wren	*Catherpes mexicanus*	1
Great-tailed Grackle	*Quiscalus mexicanus*	3
Total		34

Appendix 1. Copy of data form used for peregrine falcon monitoring at Lake Mead National Recreation Area.

LAKE MEAD NRA: PEREGRINE FALCON MONITORING
OCCUPANCY, NEST SUCCESS, PRODUCTIVITY DATA FORM

Date: _____

SURVEY TYPE: PASSIVE___ BAITED___ CALL-BROADCAST___ OTHER___
Visit No. (passive breeding)_____ (if passive): 4-hr. pm _____ 4-hr. am ____
Location Name: _____.EO #:_____. FWS #: _____ Land Ownership:_____
General Description_____

Cliff UTM:(easting):_____(northing):_____NAD 83 Zone:___
Observation Pt. UTM:(easting)_____ (northing):_____ NAD 83 Zone:___
Estimated Distance to nest cliff from Observation Pt._____. Bearing to cliff:_____
Aspect of Eyrie:_____ County:_____ 7.5'Quad:_____

Observer(s)_____Affiliation(s)_____
Observer contact info (phone or e-mail):_____
Observation Start Time:_____ Observation End Time:_____ Total (min):_____
Start Weather: Temp(°f):_____ Wind(mph):_____, (direction):_____ Cloud Cover (%):____
End Weather: Temp(°f):_____ Wind(mph):_____, (direction):_____ Cloud Cover(%):_____
General Habitat Type: _____Elev. (ft)_____

OCCUPANCY STATUS
Possible to view the nest site well enough to see eggs or young? (yes or no)_____.
No. Eggs observed:____. No. Young observed:_____
If unable to see nest site, please explain:_____.
Stage of reproduction at time of visit (courtship, incubation, nestling, fledgling, unknown): _____.

Primary Signs Of Occupancy	✓ Check
• Adult feeding young	
• Young or eggs observed with positive species I.D.	
• Adult in low posture (incubating or brooding)	
• 2 Adults / sub-adults interacting (courtship), perched or in flight	
• Adult prey exchange	
• Adult prey delivery to ledge	
• Cooperative hunting	

Age, sex & no. of Peregrines present (when known): adult male:____, adult female:____, adult unknown:____, subadult male:____, subadult female:____, subadult unknown:____, peregrine male:____, peregrine female:____, peregrine unknown:____, falcon unidentified:___.

NEST SUCCESS

Signs Of Nest Success	✓ Check
• Adult feeding young, but young cannot be seen	
• One or more nestlings observed (less than 28 days old)	
• One or more nestlings observed (≥ 28 days old)	

PRODUCTIVITY

Nest Productivity (Young Observed)	Check or Total
• No young detected	
• Number of nestlings observed less than 28 days old	
• Number of nestlings ≥ 28 days observed	
• Total Nestlings Observed	

File: LAME PEFAdataform Occupancy Success Productivity.doc
J. Barnes – Feb. 2008, from: D, Abbate - February 2006

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PEFA Occupancy, Success, Productivity Data Form *(Part 2)*

Date:_____ Location: _____ Observer(s):_____

Climbing Accessibility for Egg Collection

Climbing Information	
▪ One or more unhatched eggs observed (yes or no).	
▪ Estimated Cliff Height	
▪ Estimated Eyrie Height	
▪ Type of Eyrie (ledge, hole, crack, etc.)	
▪ Top of cliff accessible for rappel down to eyrie (yes or no)	
▪ Eyrie only accessible by climbing up from below (yes or no)	

Behavior and General Observation Notes: _____

Directions to Site and Access Information: _____

Sketch of cliff, eyrie location or other details (indicate north and use back if needed):

(check off if completed)

- ❑ Attached are 8.5 x 11 map and cliff sketches to this form indicating location, date, and observer.
- ❑ Photograph of cliff site (digital photo preferred) is attached or being sent to designated location.

Appendix 2. Copy of call-broadcast data form used for method-testing and rapid site assessment at Lake Mead National Recreation Area.

Call-broadcast Survey Form: Peregrine Falcons

Date:_____

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Survey Area:

Observers:	Survey Mode:

Location Name:		easting:	NAD 83
		northing:	Zone:
Start Time:	End Time:	Temp(°f):	Wind Speed (mph):
Distance to eyrie (m):		Response to C-B detected (Y/N):	
Period PEFA detected:		Time to detection (min.):	
Type of response:		Duration of response (min.):	
Intensity of response:		Distance to responding individuals (m):	
Number, age & sex of responding PEFAs:			
Number, age & sex detected w/o response:			
Young present (Y/N):	Breeding stage:	Interspecifics present (Y/N):	
Comments:			

Location Name:		easting:	NAD 83
		northing:	Zone:
Start Time:	End Time:	Temp(°f):	Wind Speed (mph):
Distance to eyrie (m):		Response to C-B detected (Y/N):	
Period PEFA detected:		Time to detection (min.):	
Type of response:		Duration of response (min.):	
Intensity of response:		Distance to responding individuals (m):	
Number, age & sex of responding PEFAs:			
Number, age & sex detected w/o response:			
Young present (Y/N):	Breeding stage:	Interspecifics present (Y/N):	
Comments:			

Appendix 3. Selected studies of peregrine falcon breeding populations.

Location (years)	Successful young/breeding attempt	Successful young/successful breeding pair	Breeding success rate	Density	Mean nearest neighbor distance	Reference
LMNRA (2006-09)	1.68	2.37	71%	*1 pair/ 118 km^2	6.298 km	This study
Arizona (1976-85)	1.7	2.27	73%			Ellis 1988
Utah (1984-85)	1.3	2.1				Enderson et al. 1988
Colorado (1984-85)	1.4	2.1				Enderson et al. 1988
Pennsylvania (1939-46)	1.3	2.3	80%			Rice 1969
Greenland (1981-85)	2.4	3.0		1 pair/ 192 km^2	7.7 km	Mattox & Seeger 1988
Southern Greenland (1981-85)	1.8	2.7	73%	1 pair/ 240 km^2		Falk & Moller 1988
Southern Alps (2002)	1.24	2.4	51.7%			Brambilla et al. 2004
Southern Alps (2002-04)				1 pair/ 69.9 km^2	5.391 ± 0.609 km	Brambilla et al. 2005
Northern Spain (1996)	1.45	2.23	65%			Gainzarain et al. 2000
Northern Spain (1997)	1.44	2.12	68%			Gainzarain et al. 2000
Grand Canyon, Arizona (1988-89)				1 pair/ 16.3 km^2		White et al. 2002
Britain (1945-61)				1 pair/ 52.1 km^2	4.83 km	Ratcliffe 1962

*This number represents the number of known occupied territories/available land area in LMNRA (3,765 km^2) as of the 2009 breeding season. It likely does not account for an accurate density of the entire breeding population of peregrines within LMNRA, including some areas not surveyed as of 2009.