



**Avian Monitoring in Support of North Fork of the Virgin River
Restoration, Zion National Park
(ZNP Project Number CA1590-03-003)
(UDWR Project Number 70-0607)**

2003 SUMMARY REPORT

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**UDWR Publication Number 03 – 52
31 December 2003**

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1.0 INTRODUCTION

A Cooperative Agreement (CA) was established between Zion National Park (ZNP) and the Utah Division of Wildlife Resources (UDWR) in 2003 for the purpose of implementing an avian monitoring program within ZNP along a portion of the North Fork of the Virgin River which is targeted for restoration. The CA is intended to provide guidance with the implementation of the restoration project in areas of avian habitat and to monitor avian populations.

The goals of the project are to determine breeding and migrating bird species and abundances in the restoration project area and a reference portion of the river. Data will be collected within both areas which will be helpful in determining which bird species will potentially be affected by the restoration work and to establish a baseline of avian species information with which to compare restoration efforts. These data will allow the assessment of the proposed restoration and will also provide short-term population trend information for locally breeding birds and use of the project area by seasonal migrants. If continued for several years, trend data from this study can possibly be integrated with UDWR's multi-year statewide riparian bird population trend assessments (Howe 1992, Norvell et al. 2003, In Press). Additional information concerning the restoration work is available in the CA.

2.0 PROJECT AREA AND METHODS

2.1. Project Area

The restoration project area comprises approximately 4 linear km of the river within Zion Canyon above and below Zion Lodge (Fig. 1) and includes portions of 6 vegetation types (e.g., floodplain woodland, riparian shrubland, land-use, and 3 incidental upland types). The proposed restoration portion of the river extends from the Birch Creek area to the Grotto, and the reference portion of the river extends from the Grotto to the Big Bend Area in Zion Canyon.

2.2. Assessment Methods

Our design for assessing potential avian impacts of the restoration project followed a Before-After-Control-Impact (BACI) design (Bence et al. 1996, Stewart-Oaten and Bence 2001), where a reference (i.e., control) portion of the river is assessed concurrently with assessments along the restoration portion of the river, albeit without landscape-level spatial replication due to the unique qualities of the site. Assessments of birds within both the restoration and reference areas was accomplished by conducting point transects and constant-effort mist net sampling at selected locations. Field sampling methods followed established UDWR riparian survey protocols (Howe 1992, Parrish 1995, Howe et al. 1999).

2.2.1 Point Transect Sampling

Point transects were selected by overlaying an orthoquad map of the project area with a randomly placed sampling frame using ArcView (ESRI, v3.2, MILA Utilities). The sampling frame was limited to a maximum width of 200 m either side of the river and to slopes less than 35% to ensure comparable coverage of the intended impact area and for safety of field personnel. All point transect locations were selected via a systematic random plot design in order to ensure thorough spatial coverage of the site (a stated sampling prerequisite – S. Kim, Pers. Comm.). Detailed point location descriptions (Appendix A, B) and maps are provided (Fig. 2 and 3).

All point transects were sampled three times between May 1 and June 30 in order to focus on locally breeding birds during their most detectable and numerically

stable portion of the year. Point transect sampling began within one-half hour of official sunrise and continued until approximately 10:00 AM on scheduled sampling days (Howe 1992, Ralph et al. 1995, Norvell et al. 2003, In Press).

Point transects differ from point counts in that exact distance from the bird detected to the point location is recorded for each observation. In addition, species identification, age, sex, detection period (i.e., 8 minute total count time recorded in three consecutive time periods: 0-3 minutes, 3-5 minutes, and 5-8 minutes), type of detection (i.e., audible, visual, or both) and on-site weather data are also recorded.

Regionally averaged encounter rates for each species (i.e., the expected mean number of observations per kilometer of transect surveyed) drawn from our on-going statewide riparian bird/habitat study, Howe 1992, Howe et al. 1999, Norvell et al. 2003, Norvell et al. *In Press*) indicate it's unlikely we'll have sufficient data to estimate density for all but the most common 10-15 species until the third year. It is possible, however, to bridge relatively small data sets ($20 < n < 80$ observations/strata, if without substantial [$<15\%$] bias or error) off regionally derived detection functions in order to estimate local density (Buckland et al. 2001). Since 2003 was a pilot year, our overall analysis approach was to estimate only the density of sufficiently abundant bird species (however, relative abundance [RA] values were calculated for all species, below). We set the minimum threshold for analysis at 20 non-'flyover' observations summed between both areas, and five species made that cut: Ash-throated Flycatcher (*Myiarchus cinerascens*), Black-headed Grosbeak (*Pheucticus melanocephalus*), House Wren (*Troglodytes aedon*), Warbling Vireo (*Vireo gilvus*), and Yellow Warbler (*Dendroica petechia*). Species lists, relative abundances, and measures of community diversity were also calculated for the restoration and reference survey areas.

2.2.1.1 Power Analyses

Within the BACI framework, 12 point transect sampling design variations were evaluated (Fig. 4 shows the estimated power [$1 - \beta$] for 12 designs [3 durations x 2 visit designs x 2 levels of within treatment sampling effort]). Sampling duration for the pre-impact, baseline data collection period was forecast for three periods (3, 5, and 8 years, with annual survey frequency). Two levels of within-year effort (2 and 3

visits/yr) were evaluated, and the number of replicate (independent) samples taken in each of the treatments was evaluated at both 7 and 15.

In addition, 3 sample randomization schemes are discussed: 'Full-temporal', 'Full-spatial', and 'Mixture-design'. Statistically speaking, these three differ primarily in which assessment goal they meet most efficiently. Logistically speaking, they differ in the degree to which point transect locations are re-randomized between visits within each year and between years, and hence cost due to repeated set-up time.

2.2.1 Constant-Effort Mist Net Sampling

Potential mist net locations were also selected by overlaying an orthoquad map of the project area with a randomly placed sampling frame using ArcView (ESRI, v3.2, MILA Utilities). The sampling frame was limited to a maximum width of 200 m either side of the river and to slopes less than 35% as with the point transect selection procedures. The area within this potential sampling frame was then surveyed on foot to identify the best location for placement of individual mist nets. A critical factor in selecting a given area for placement of mist nets is concealment. Nets randomly placed in open areas without sufficient vegetative cover are rendered too visible and birds simply avoid the nets and are not captured. In this manner, ten separate locations for placement of mist nets were identified in both the restoration and reference areas (20 locations total). Details of mist net placements (Appendix C) and maps are provided (Fig. 5 and 6).

In addition to UDWR riparian sampling protocols mentioned above, mist net sampling followed protocols established by the Monitoring Avian Productivity and Survivorship (MAPS) program (DeSante et al. 1995). The MAPS protocols are designed primarily for assessing avian populations during peak breeding periods but are equally useful in assessing use of areas by seasonal migrants.

Constant effort mist net sampling was conducted by trained field personnel once each 10-day period between late-August (Julian Date 237) and late-September (Julian Date 251). The restoration and reference areas were sampled simultaneously on each scheduled sampling day. Mist nets were opened within one-half hour of official sunrise and operated for a continuous 6-hour period. Net runs were conducted approximately

once each hour, and captured birds were fitted with numbered leg-bands and released. Each bird captured was also identified as to species, age, sex, general condition, and an assessment was also made as to the amount of fat present. Metabolism of stored body fat is the primary energy source for birds during long-distance migration flights (see Roberts et al. In Press). Results were entered onto a laptop computer in the field and subsequently transferred to a computerized database.

3.0 RESULTS AND DISCUSSION

3.1. Point Transect Surveys

A total of 36 species were detected in the restoration area, and a total of 28 species were detected in the reference area during point transect surveys conducted during 2003. For both areas combined, a total of 42 species were detected during 2003. Of these, 34 species (81%) were Neotropical migrants. (Table 1).

Since no restoration impacts had yet occurred during the 2003 survey period, we did not expect large differences between the restoration and reference areas. However, with only 22 of the 42 species found in both areas (a Sorenson's Community Percent Similarity Index value of 40.7%, Magurran 1988), these areas do not appear to contain nearly identical bird assemblages as was initially expected. Also, since the observers were experienced, well matched in ability, rotated between areas, and visits to both areas occurred simultaneously, there is little *a priori* reason to suspect this difference is an artifact of anything but real difference and/or the small sample size.

Temporal variability between visits was larger for the restoration area, with the difference in new species observed (Table 2 Richness Results) accounting for most of the observed differences. Both areas showed fairly high (as compared with UDWR unpublished data from multi-year riparian studies), but similar, point-to-point variability in richness (see Table 2), yet both had fairly low (and yet similar) maximum number of species recorded at a point. These values indicate a fairly high turnover rate in species composition occurred in 2003 (high patchiness at small spatial scales). The seven unidentified species listed in Table 2 were attributed to the difficulty in chasing down partial observations due to time, terrain, and interactions with park visitors.

Diversity measures (H' , the Shannon-Wiener index [Magurran 1988], was calculated for the restoration and reference areas using the mean relative abundance (RA) and frequency of observation (OBS) as the parameter of interest) are provided in Table 3. Measures of community diversity such as Shannon-Wiener combine the number of categories with the RA (or frequency) of each and tend to favor certain aspects of community measures tempering straightforward interpretation. As the Shannon-Wiener index favors richness over dominance, the substantially larger H'_{RA} values for the

restoration area were expected given its higher overall richness. Calculated H' values are much closer between the two areas although favoring the restoration area.

Relative abundance values for all identified species are given in Table 4, along with the mean RA per point and rank within the area. Note that ranking RA values implies an equal probability of detection for all species, an assumption that does not hold (Table 5, Norvell et al. 2003), and are solely provided for information purposes, not analysis. The species list for the two areas (Table 1) and RA values (Table 4) indicate the bulk of the observed differences in bird assemblages comes from observation of species more closely associated with piñon-juniper or other upland habitats. Species typically associated with riparian habitats, our focal habitat here, appear much more similar than overall community metrics imply.

The 'bridged' density analysis results are shown in Table 5. Of the five species with more than 20 non-'fly-over' observations (i.e., Ash-throated Flycatcher (ATFL), Black-headed Grosbeak (BHGR), House Wren (HOWR), Warbling Vireo (WAVI), and Yellow Warbler (YWAR), all but ATFL may be considered 'riparian-associated' species in southern Utah deserts though not necessarily elsewhere in their ranges. Globally derived unconditional probabilities of detection (p) were calculated for each of these five species from UDWR's riparian study (regional data, 1999-2001) and applied to the 2003 project area data following methods outlined in Buckland et al. (2001). Estimated densities ($\hat{D}$ as percent probability of detection) and abundances (N as birds/ha) were calculated using Program Distance (v3.5.6, Thomas et al. 1998) for the restoration and reference sampling areas and for the pooled data (averaged over both sites). As the detection function was provided, and not estimated from the data, all expressions of variability are derived from the local and not the regional data. A substantial underreporting of variance can result if the assumption of coherence between the local 2003 detectability and the pooled 1999-2001 regional detectability does not hold. However, until additional data has been collected locally, this assumption cannot be tested. Even so, the respectable-to-very-low pilot year CV's seen for $\hat{D}$ (range, pooled data: 8.1% - 20.72%; Table 5) do imply some hidden bias here, given that none of these species reached the recommended minimum number of observations (60-80) for

density analysis from point transect data using Program Distance. For results thus far, greater reliance and emphasis should be placed upon the pooled data section *N*s, with the large confidence intervals reflecting the credentials of the data: With the relatively large point-to-point variability observed in 2003, a substantial degree of uncertainty is appropriately reflected in the abundance estimates.

3.2. Power Analyses

The 'Full Spatial' and the 'Full Temporal' designs emphasize different —and competing— ends of the assessment spectrum (spatial contrast versus population trend) through the selection of random samples. The Full Spatial approach re-randomizes every point on every visit, thus maximizing independent sample size, and hence power. This additional power comes at the prohibitive cost of more than doubling the set-up time required and was not selected for this reason.

The choice between the Full Temporal and Mixture design options need not be made until the second season. The Full Temporal approach minimizes the 'noise' of spatial variation through the use of fixed sample locations and has the lowest set-up cost, but has relatively low power to detect differences between treatments and may not give well-conditioned baseline data if there is important local spatial variation in distribution and abundance (e.g., see Larson et. 2001). The "Mixture" design is promising. It is intended to bolster sample size (through the re-randomization of a sizable proportion of each visit's effort, say 50%) while abating the 'noise' of spatial variance somewhat for trend analysis purposes (by keeping 50% of the sample points fixed through all the years of the study). This is an attractive idea and one that is gaining favor with several biological assessment programs with multiple study goals and scales of interest (e.g., EMAP, Baker et al. 1997), but one that is difficult to assess in terms of power since currently available software does not address this design. However, and as might be expected, its estimated costs are somewhere between the other two. Ultimately, in 2003 we opted for the use of 15 'fixed' points in each of the two study sites, visited twice; it is still possible to do either a partial or complete re-randomization of the points for subsequent years and to add a third visit if so desired.

3.3. Constant-Effort Mist Net Surveys

A total of 74 birds representing 23 species were captured in the restoration area, and a total of 63 birds representing 20 species were captured in the reference area during mist net surveys conducted during 2003. For both areas combined, a total of 137 birds representing 30 species were captured, of which 23 species (77%) were Neotropical migrants. Of these, a total of 12 species were captured in both the restoration and reference areas, 10 species were captured only in the restoration area, and seven species were captured only in the reference area (Table 1).

Mist net surveys have been shown useful in capturing species that are not detected during point transect surveys in a given area, especially when the two sampling efforts are not conducted in concert within a given area. A total of 52 individuals representing 12 species were captured during mist net surveys that were not detected during point transect surveys (Table 1). Although several of these additional species captured could potentially breed within the project area, at least five species, Blue-headed Vireo, Brewer's Sparrow, Cassin's Vireo, Chestnut-sided Warbler, and Yellow-breasted Chat most likely were migrants that do not breed within Zion National Park.

Of the 137 total birds captured, 74 (54%) were captured in the restoration area (Fig. 6). Within mist nets located in the restoration area, 80% of the captures occurred at nets 1, 3, 5, 8 and 10, and within the reference area 76% of the captures occurred at nets 11,13, 14, 17, and 18. No foreign recoveries (i.e., birds originally banded outside Zion National Park) occurred during mist net surveys, and all recaptures recorded involved birds that were either originally banded during the first day or in subsequent periods of mist net sampling within the project areas.

A comparison was made with the combined captures within the restoration and reference areas with ongoing mist net surveys at over 30 riparian sites statewide. It should be noted, however, that the statewide mist net surveys have been targeted at assessing birds during potential breeding seasons, although some fall migration monitoring has taken place.

At least two other sites in southern Utah have been sampled occasionally during fall migration periods since 1994, one site located just south of Gunlock Reservoir along the

Santa Clara River in Washington County, and another site located along Cottonwood Creek in Grand Staircase-Escalante National Monument in Kane County. A total of 25 species have been recorded after Julian Date 237 at the Washington County site, 13 of which were also captured within the restoration and reference project areas. A total of 17 species have been recorded during the same time period at the Kane County site, 13 of which were also captured within the restoration and reference project areas. In addition, two of the species captured within the Zion Canyon project areas, Chestnut-sided Warbler and Blue-headed Vireo, have not been recorded at any other banding site during any time period since 1994.

In conclusion, the 30 species captured during the 2003 mist net surveys represents the highest number of species recorded thus far at any other riparian monitoring site after Julian Date 237. A more intensive mist net sampling effort within the project areas will likely result in considerably more species being recorded that are using those portions of the Virgin River during migration periods.

4.0 SUMMARY

Riparian habitat in Utah comprises only 0.7% of the total landscape, yet is used by over 85% of the state's avian resources (Parrish et al. 2002), and the significance of impacts to riparian systems within the Utah landscape cannot be overemphasized. Riparian habitat has been designated as a critical component of the UDWR Essential Wildlife Habitat designations and UDWR's Habitat Management Initiative. In addition, protection of riparian habitat is obligated under the Endangered Species Act, Clean Water Act, North American Wetlands Conservation Act, and Presidential Executive orders representing NTMB's.

The data from this pilot year generally indicate two things: one, that this is quite a rich and diverse site, and two, that with 41 species observed on just two point transect surveys and no more than 9 at any given point, there is a fairly high degree of spatial variation in bird density, richness, and diversity at the local scale. This is not necessarily a problem for our analysis if temporal variation is either small (which is unlikely, given results from UDWR study results) or consistent between sites (which is quite likely, as might be expected from temporal effects which are typically 'applied' over large extents, e.g., weather). The data do make it clear that with the unique study setting and the rich spatial variability we've seen in the bird community metrics, a step up in spatial sampling intensity (with a either third visit or more points) would help ensure we achieve the desired statistical power for impact assessment in good time. If study goals shift toward long(er) term trend estimation over impact assessment, then continuing with the current design will minimize spatial variation to that end.

A comprehensive assessment of the project area in terms of use by migrants is not possible with only a portion of one fall season of sampling effort. It is recommended that either daily or multiple periods of consecutive days of mist net surveys be conducted in the project areas. Such sampling events should begin in early-August and continue through mid-October annually in order to more accurately assess use of the area by fall migrants. Suggested time frames for similar surveys for spring migrants are early-April through late-May.

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Table 1. Avian species detected during 2003 point transect and constant-effort mist net surveys conducted within two portions of the Virgin River in Zion Canyon (See text for details)

SPECIES	POINT TRANSECTS		MIST NET SURVEYS		NEOTROP
	REST ¹	REF ¹	REST ¹	REF ¹	
American Goldfinch	X				X
American Robin	X	X			X
Ash-throated Flycatcher	X	X			X
Black Phoebe	X	X			X
Black-capped Chickadee	X	X	X	X	
Black-chinned Hummingbird				X	X
Black-headed Grosbeak	X	X			X
Black-throated Gray Warbler	X	X			X
Blue Grosbeak		X			X
Blue-gray Gnatcatcher	X	X	X	X	X
Blue-headed Vireo			X		X
Brewer's Sparrow				X	X
Broad-tailed Hummingbird	X		X	X	X
Canyon Wren		X	X		
Cassin's Vireo				X	X
Chestnut-sided Warbler			X		X
Chipping Sparrow	X			X	X
Common Black-Hawk	X				X
Common Bushtit			X	X	
Common Raven	X	X			
Downy Woodpecker	X		X		
Dusky Flycatcher	X		X		X
Green-tailed Towhee	X				X
Hairy Woodpecker	X	X			
House Finch	X				X
House Wren	X	X	X	X	X
Juniper Titmouse	X		X		
Lazuli Bunting	X	X		X	X
Lesser Goldfinch	X	X			X
Lincoln's Sparrow			X		X
MacGillivray's Warbler	X	X	X		X
Mallard	X				
Mourning Dove	X	X			X
Orange-crowned Warbler	X		X		X
Plumbeous Vireo	X	X			X
Rock Wren		X			
Rufous Hummingbird			X	X	X
Say's Phoebe		X			X
Song Sparrow	X	X	X	X	X
Spotted Towhee	X	X		X	X

Steller's Jay				X	
Turkey Vulture	X	X			X
Unid. Flycatcher		X			
Unid. Hummingbird	X	X			
Unid. Passerine	X	X			
Unid. Sparrow		X			
Unid. Swallow		X			
Unid. Warbler		X			
Unid. Woodpecker	X				
Violet-green Swallow	X	X			X
Warbling Vireo	X	X	X	X	X
Western Scrub-Jay			X	X	
Western Tanager		X			X
Western Wood-Pewee	X		X		X
White-crowned Sparrow			X	X	X
White-throated Swift	X				X
Wild Turkey	X				
Wilson's Warbler		X	X	X	X
Yellow Warbler	X	X	X	X	X
Yellow-breasted Chat			X	X	X
TOTAL SPECIES	36	28	23	20	41

¹ REST = Restoration Area; REF = Reference Area

Table 2. Avian species richness values calculated from data collected during point transect surveys conducted within two portions of the Virgin River in Zion Canyon during 2003. (Values do not include detections that were labeled as unknowns or flyovers; see text for details)

RICHNESS	RESTORATION AREA	REFERENCE AREA
Total	34	26
Visit 1	20	20
Visit 2	29	21
Mean/Visit	24.5	20.5
SEMean/Visit	4.5	0.5
Mean/Visit/Pt	4.37	4.73
SEMean/Visit/Pt	0.41	0.32
Mean/Pt: Visit 1	4.33	4.40
SEMean/Pt: Visit 1	0.52	0.36
Mean/Pt: Visit 2	4.40	5.07
SEMean/Pt: Visit 2	0.66	0.52
Min/Pt: Visit 1	1	2
Max/Pt: Visit 1	7	7
Min/Pt: Visit 2	1	1
Max/Pt: Visit 2	9	8
GRAND TOTAL	41 SPECIES	

Table 3. Shannon-Wiener diversity index ($H' = -\sum_{i=1}^S \frac{n_i}{N} \times \log_2 \left(\frac{n_i}{N} \right)$, where N = total number of individuals, S = number of species, and n_i = number of individuals in sample i). The index, with variance, has been calculated using both relative abundance (RA) and frequency of observation (OBS) to explore RA's sensitivity to extreme values (See text for further explanation).

DIVERSITY (H')	RESTORATION AREA	REFERENCE AREA
H'_RA	3.12002	2.97
var H'_RA	0.0004371	0.0003845
H'_OBS	3.04577	2.93
var H'_OBS	0.0005645	0.0004428

Table 4. Relative Abundance (RA). Species codes are given in Appendix 1. Note that species "RA rank" is given for convenience only, and are not suitable for analysis purposes due to the untenable assumption of equal probability of detection.

RA	REFERENCE AREA				RESTORATION AREA			
Species	RATotal	MeanRA/Pt	SEMeanRA/Pt	RA Rank	RATotal	MeanRA/Pt	SEMeanRA/Pt	RA Rank
AMGO	*	*	*	*	1	1	*	29.5
AMRO	4	1	0	13	6	1	0	10
ATFL	13	1	0	5	13	1	0	3
BCCH	3	3	*	16	1	1	*	29.5
BGBK	1	1	*	23	*	*	*	*
BGGN	15	1.07	0.07	3.5	3	1	0	17
BHGR	8	1	0	8	12	1.09	0.09	4.5
BLPH	2	1	0	18.5	2	1	0	21.5
BTLH	*	*	*	*	1	1	*	29.5
BTYW	1	1	*	23	3	1.5	0.5	17
CBHA	*	*	*	*	1	1	*	29.5
CHSP	*	*	*	*	2	1	0	21.5
CORA	3	1	0	16	5	1	0	11.5
CYNW	8	1	0	8	*	*	*	*
DOWO	*	*	*	*	3	1.5	0.5	17
DUFL	*	*	*	*	1	1	*	29.5
GTTO	*	*	*	*	1	1	*	29.5
HAWO	2	2	*	18.5	1	1	*	29.5
HOFI	*	*	*	*	2	1	0	21.5
HOWR	15	1.07	0.07	3.5	10	1	0	6
JUTI	*	*	*	*	4	1	0	14

LAZB	10	1	0	6	4	1	0	14
LEGO	1	1	*	23	4	1.33	0.33	14
MACW	4	1	0	13	1	1	*	29.5
MALL	*	*	*	*	7	7	*	8.5
MODO	3	1	0	16	2	1	0	21.5
OCWA	*	*	*	*	1	1	*	29.5
PLVI	4	1	0	13	12	1	0	4.5
ROWR	1	1	*	23	*	*	*	*
SAPH	1	1	*	23	*	*	*	*
SOSP	8	1	0	8	7	1	0	8.5
SPTO	7	1.17	0.17	10	2	1	0	21.5
WAVI	21	1.11	0.11	1	26	1.04	0.04	1
WESJ	1	1	*	23	2	1	0	21.5
WETA	1	1	*	23	*	*	*	*
WITU	*	*	*	*	8	8	*	7
WIWA	5	1.67	0.67	11	*	*	*	*
WTSW	*	*	*	*	1	1	*	29.5
WWPE	*	*	*	*	5	1	0	11.5
YWAR	19	1.06	0.06	2	20	1	0	2

Table 5. Estimated density and abundance for five species (with >20 non-flyover observations) with CV and 95% confidence intervals, for the Reference, Restoration, and overall (Pooled) areas. Note that the global unconditional probability of detection for each species, p , was estimated from UDWR's riparian bird survey data in the region, 1999-2001. If either the 1999-2001 time period, or the regionally averaged p (or both), is not a good model for these 2003 Zion data, then these $\hat{D}$ and N estimates may be potentially biased to an unknown degree in an unknown direction. It is unlikely that this is true given the generally robust properties of the estimator; however, the very small CV's seen are likely too optimistic, reflecting only the local between point spatial variance, and the (minimal, as compared to year-to-year) between visit temporal variance (See text for further explanation).

	SPECIES	ATFL	BHGR	HOWR	WAVI	YWAR
	Global p	0.297	0.371	0.434	0.333	0.367
	Global SE p	0.033	0.020	0.045	0.007	0.021
REFERENCE AREA	$\hat{D}$	0.711	0.408	0.629	0.629	0.659
	CV $\hat{D}$	16.28	5.41	14.17	12.15	10.85
	CI Low	0.493	0.365	0.471	0.492	0.527
	CI High	1.026	0.455	0.842	0.805	0.822
	N	41	23	36	36	38
	CI Low	28	21	27	28	30
	CI High	59	26	48	46	47
RESTORATION AREA	$\hat{D}$	0.547	0.611	0.779	0.736	0.739
	CV $\hat{D}$	11.26	21.56	17.48	12.65	13.24
	CI Low	0.437	0.380	0.510	0.566	0.557
	CI High	0.686	0.983	1.191	0.956	0.981
	N	71	79	101	95	96
	CI Low	57	49	66	73	72
	CI High	89	127	154	124	127
POOLED	$\hat{D}$	0.619	0.509	0.682	0.684	0.698
	CV $\hat{D}$	17.32	20.72	14.67	8.1	8.12
	CI Low	0.070	0.038	0.107	0.245	0.249
	CI High	5.497	6.894	4.356	1.911	1.954
	N	36	29	39	39	40
	CI Low	4	2	6	14	14
	CI High	316	396	250	110	112

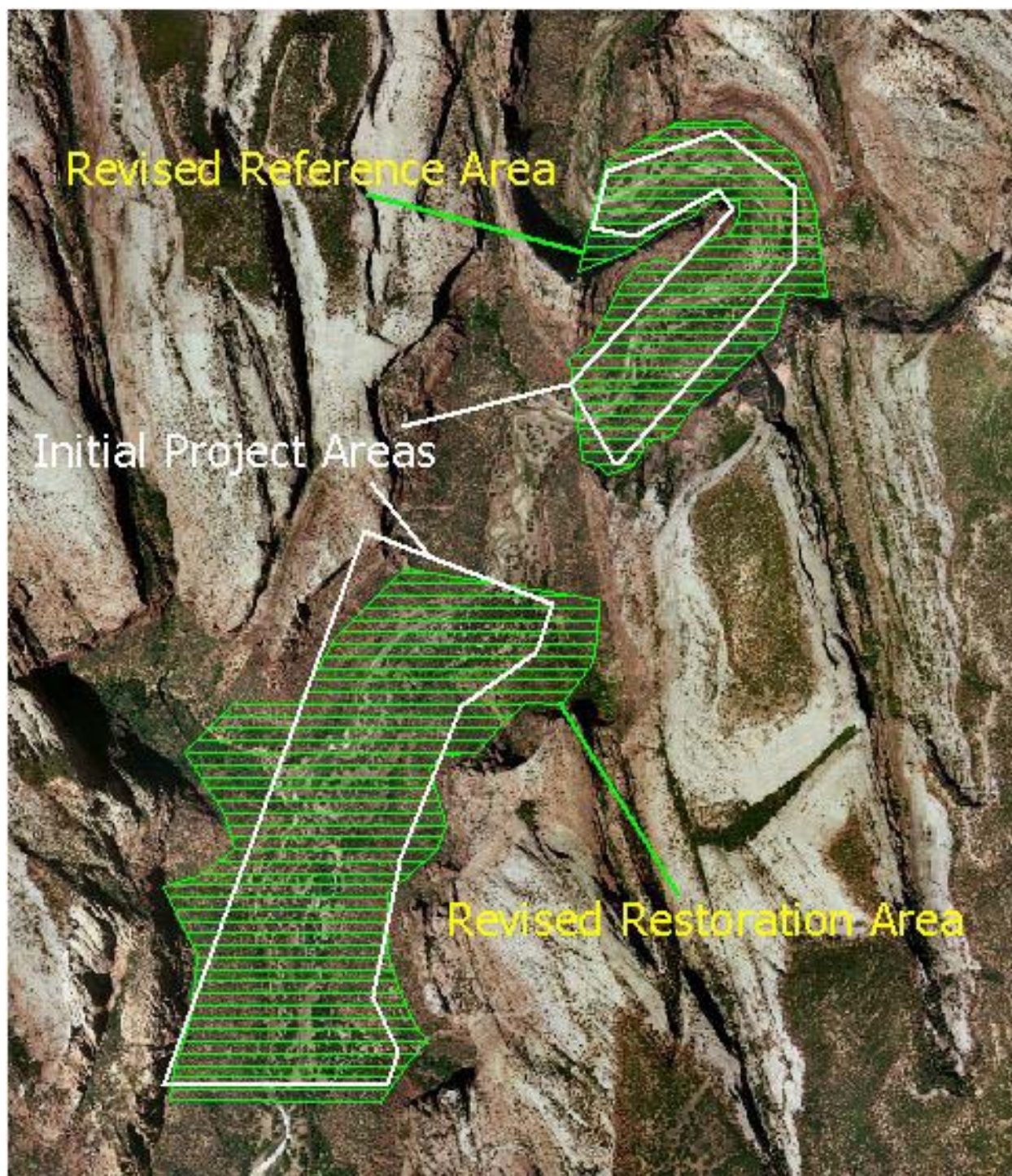


Figure 1. Location of Virgin River Reference and Restoration Project areas within Zion Canyon, Zion National Park.

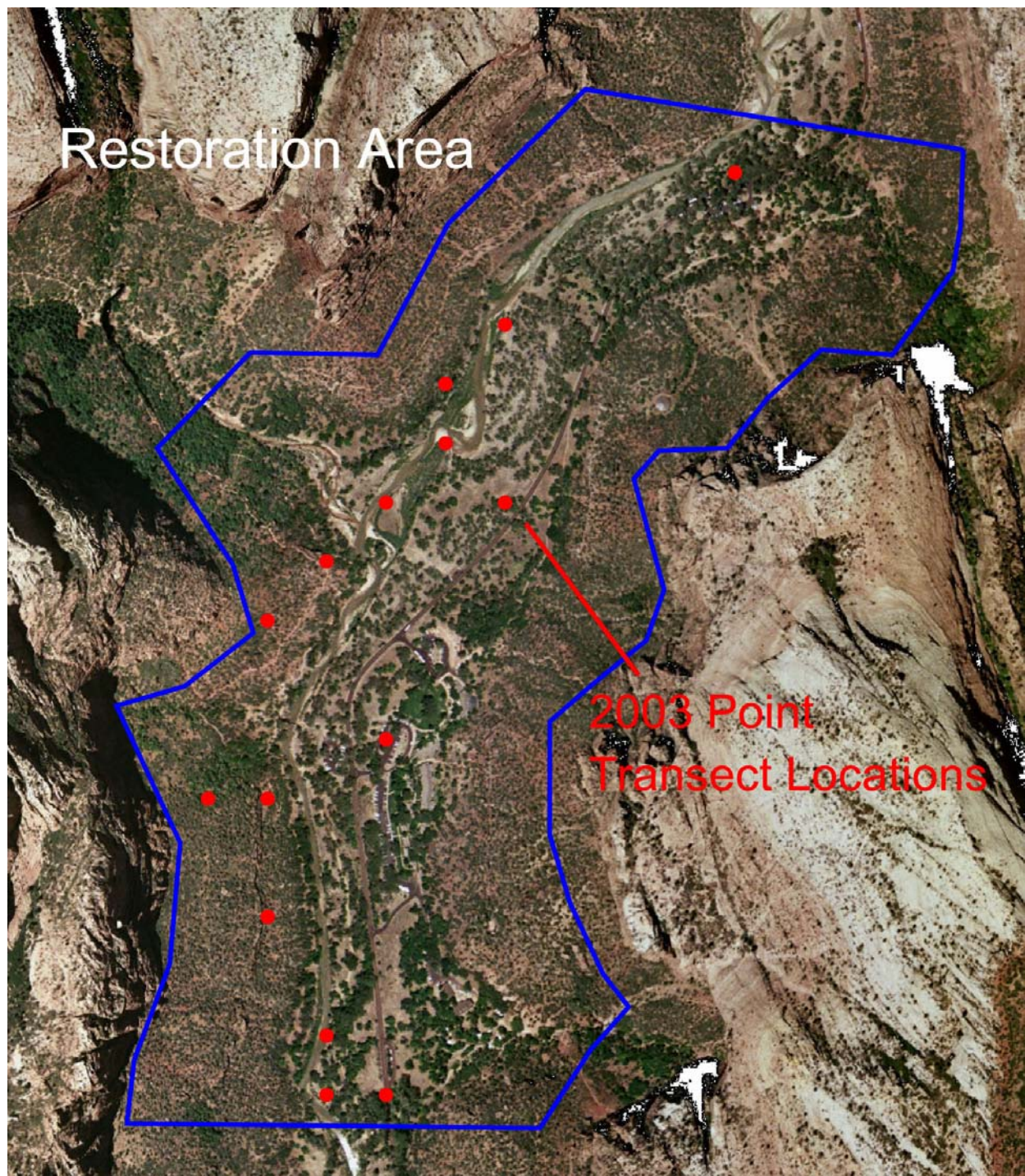


Figure 2. Location of point transects within the revised restoration project area within Zion Canyon, Zion National Park.

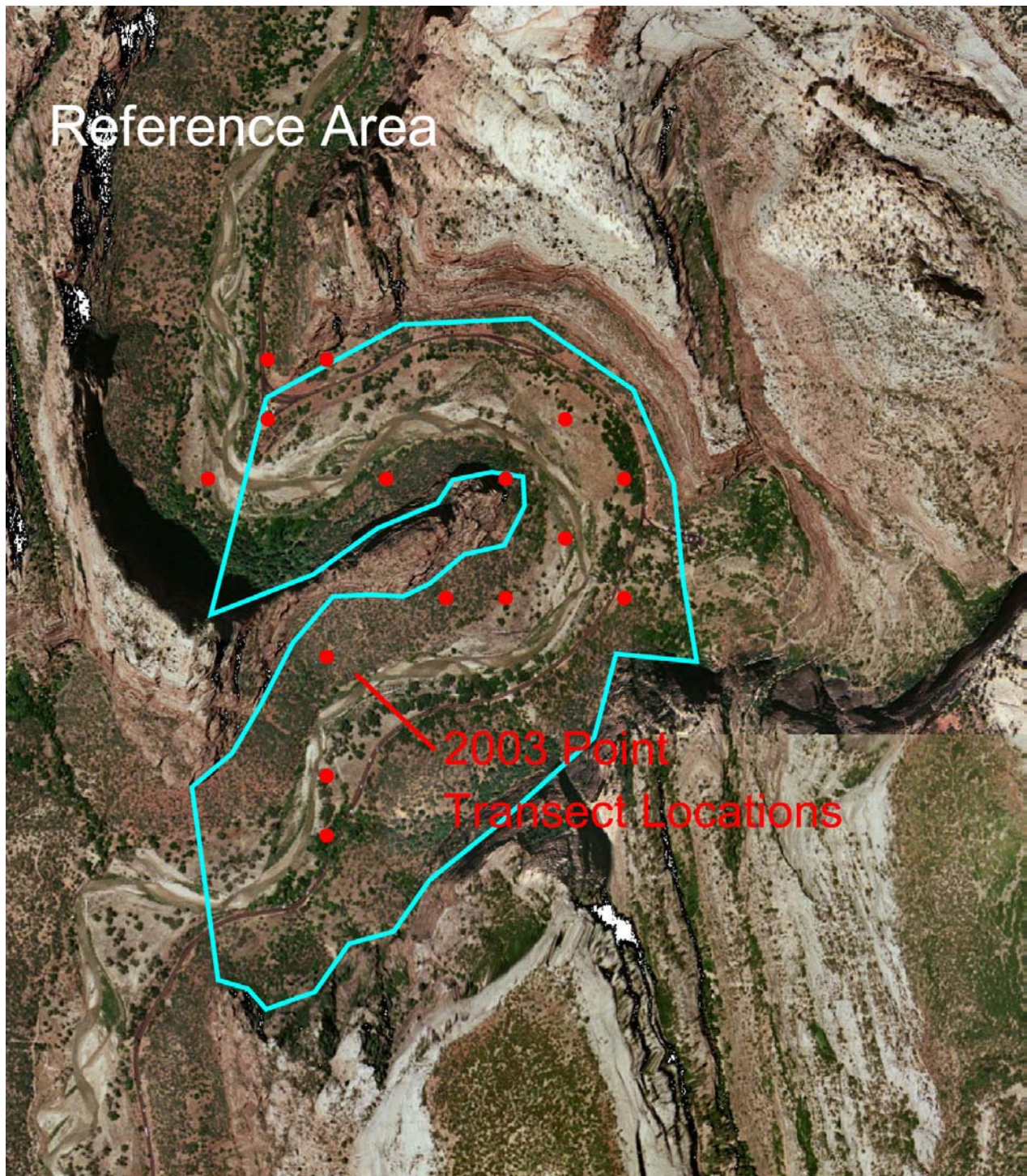


Figure 3. Location of point transects within the revised reference portion of the project area within Zion Canyon, Zion National Park.

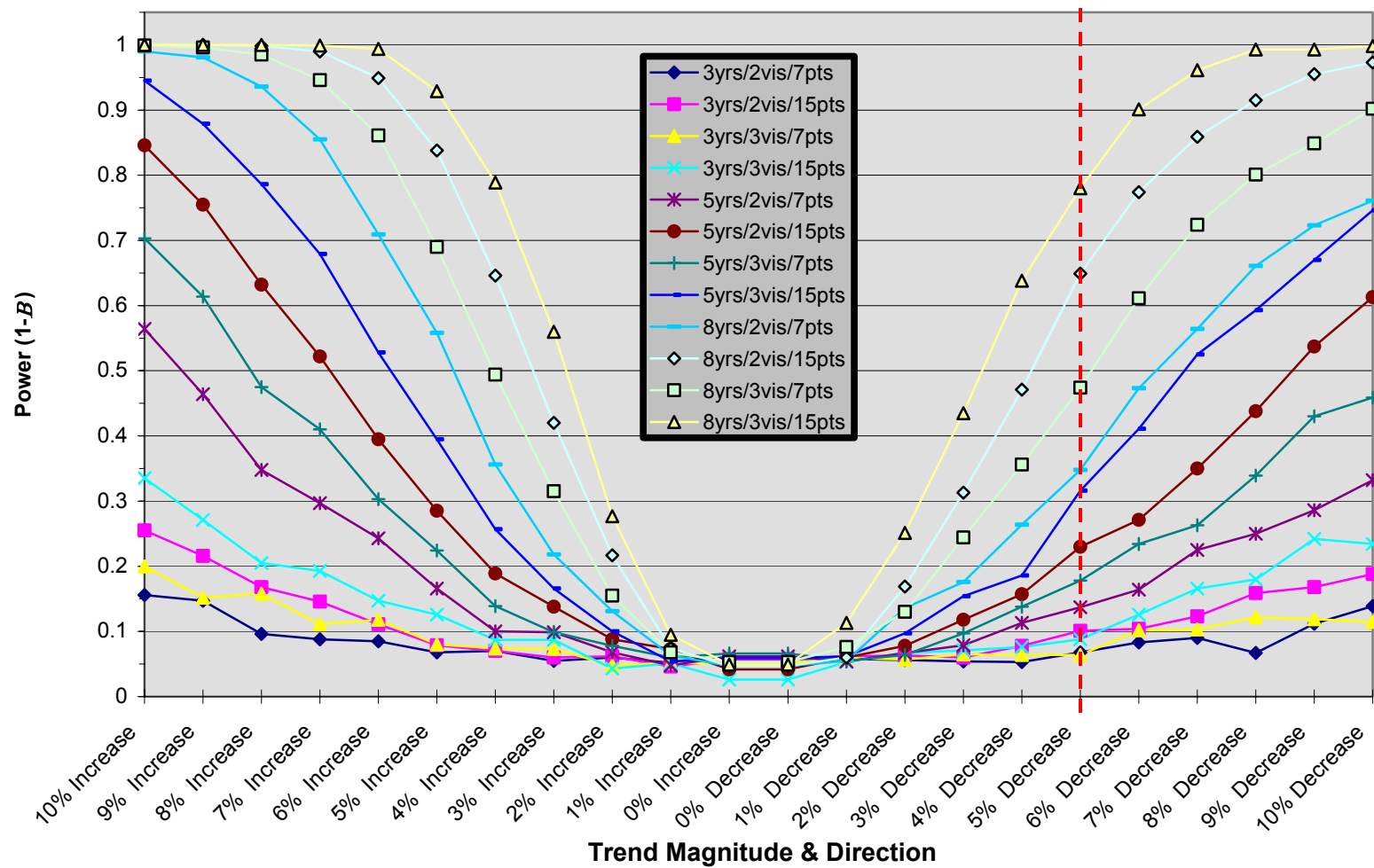


Figure 4. Analysis of potential power of various sampling designs to predict increases and decreases in avian populations along portions of the Virgin River within Zion Canyon, Zion National Park.

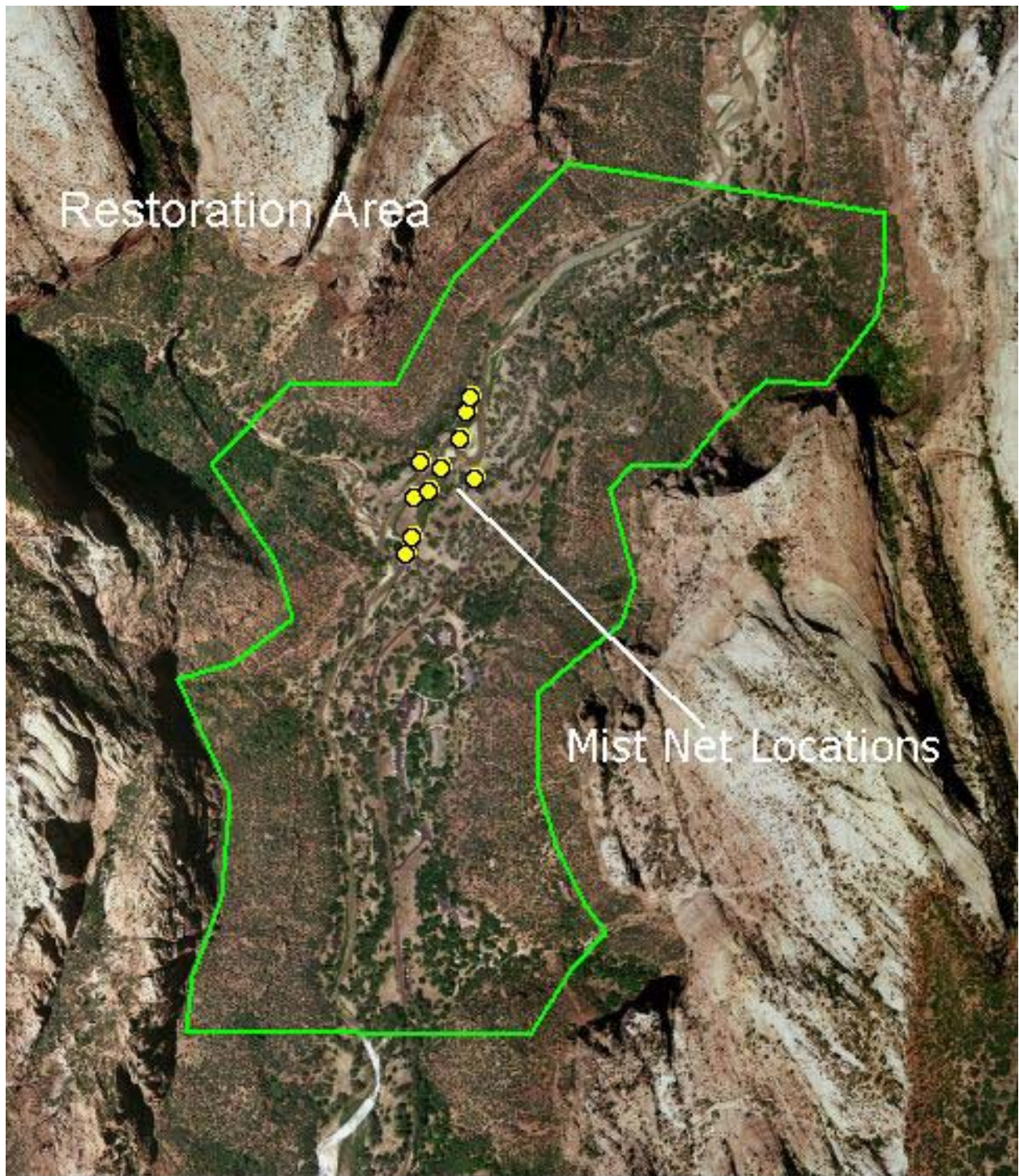


Figure 5. Location of mist nets within the revised restoration portion of the project area within Zion Canyon, Zion National Park.

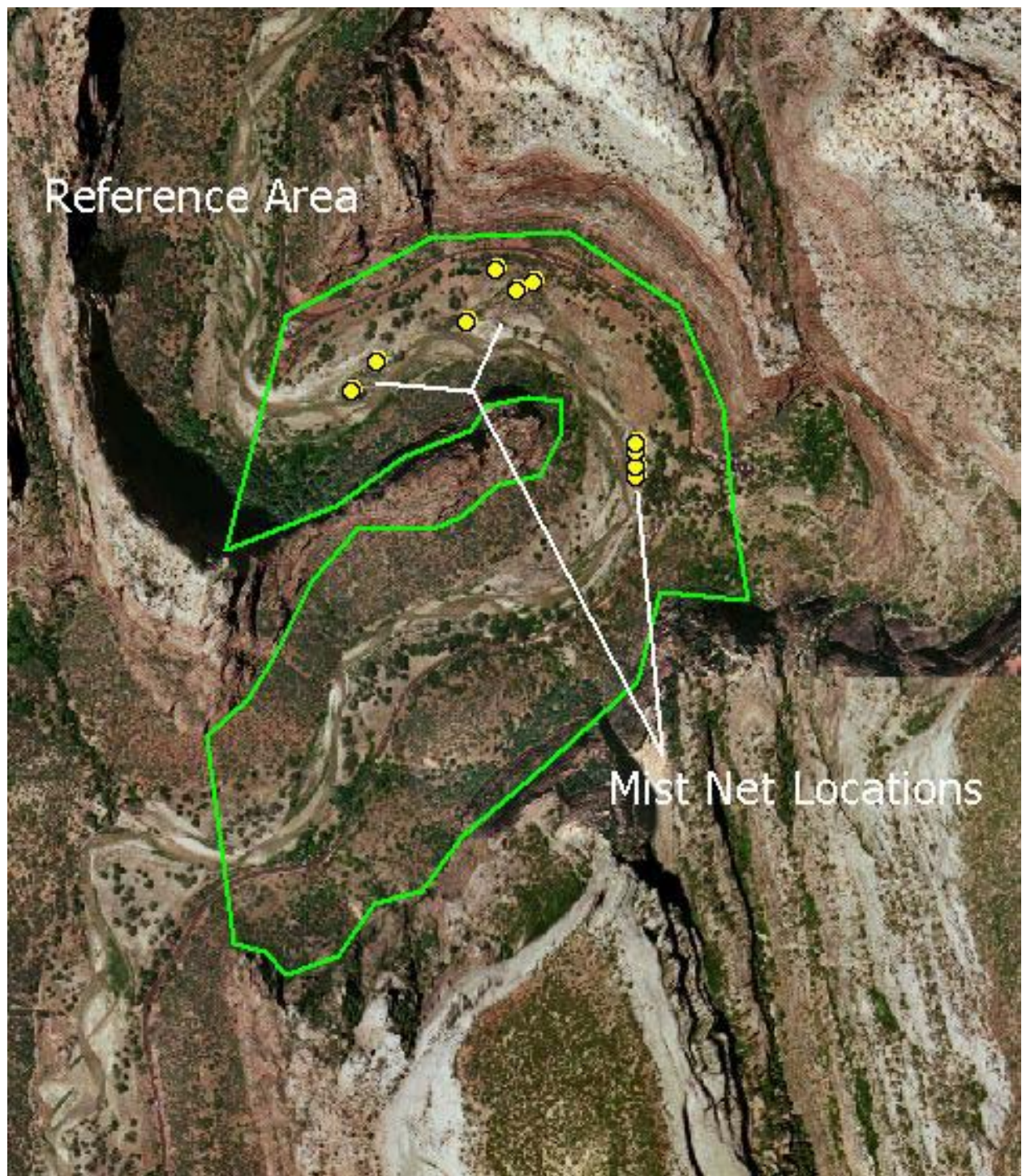


Figure 6. Location of mist nets within the revised reference portion of the project area within Zion Canyon, Zion National Park.

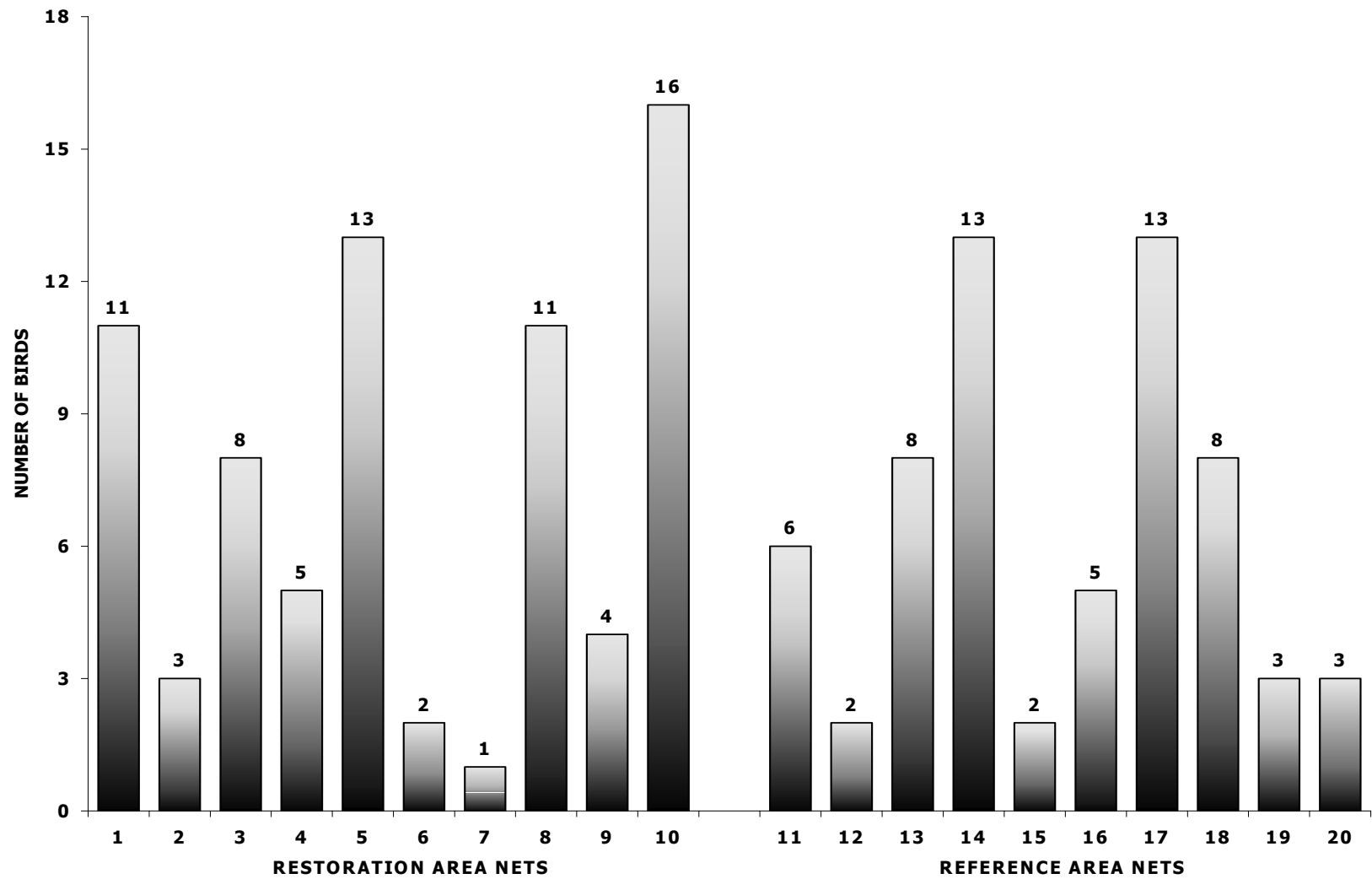


Figure 7. Number of birds captured at mist net locations established in the restoration and reference areas along the Virgin River in Zion Canyon during 2003.

6.0 APPENDICES

APPENDIX A. 2003 POINT TRANSECT DESCRIPTIONS

Reference Area: Points 16-30

Note: Aerial photos are a must for this count; GPS is not reliable in the canyon. Look for rock cairns as point markers, that is all you have to go on. Contact Park Biologist Sharon Kim for permission pass and accommodations.

(Listed in recommended count order)

Enter Zion Park main canyon; make your way up to the Big Bend Shuttle turn out behind Angel's Landing.

- **Point 29** - Just past Big Bend shuttle stop main road takes a sharp right (North). Just up the main road there is a small turn out on your right. The point is at the south end of that little turn out under a large maple (Box Elder). Look for cairn. Consult aerial photo.
- **Point 27** - Go back to Big Bend shuttle stop. Look for monument that reads "Canyon or Cathedral". Just past this monument there is a small trail that leads back to an old juniper with a double trunk with a small rock in it; that's the point (go 20m @ 200° from monument). Look for cairn. Consult aerial photo.
- **Point 30** - Go back up to main road. There is a right turn sign "↗" a little ways down road BEFORE the Big Bend shuttle stop. 10.5 meters before the turn sign there is a small dirt trail that goes up from the north side of the road. Take this trail up the hill until it forks. Take left fork up and over. Point is a cairn on a large boulder just of right side of trail. There should be several Yucca plants just to the left (south) of you. Looking down at the main road you should be even with a brown wooden sign (Big Bend) with two posts. Consult Aerial Photo.
- **Point 23** - Go back to point #27. On your right a trail leads down behind the hill to the Virgin River. Go down to river and cross it where it "bends". Once you are on the other side look for a small trail that heads towards the cliffs. If you find it get on it and walk until you see a small brown plastic sign with a picture of a suspended climber on it stuck in the ground. Go 17 paces past that sign toward cliffs until you come to a spot where there are two rotten logs on either side of the trail. That's the point. Look for cairn. Consult aerial photo.
- **Point 24** - From point #23, get back in the river and head downstream. Shortly, you will come to a large cottonwood on the left. Just past that cottonwood, there are some diagonal small rapids in the river. Cross here to the South side of the river to the grove of Gambel's Oak and Maple. There is a small trail that starts near a square red sandstone boulder. Take this trail. You will come to a clearing. On your right, there are numerous oak trees. Look for a 5-foot tall oak snag. 1.5 meters SE of that snag is the point. Look for cairn. Consult aerial photo.
- **Point 25** - Proceed downstream or along ridge. You will pass a grove of older maples and oaks. You are heading to the north end of "The Organ." You'll pass an area from which tamarisk has been removed. Then you'll come to a sandbar island. Just after that island, go up the embankment (look for cairn). You'll see a

large boulder tilted at a 45 degree and a skimpy, tall, skinny cottonwood about 30 meters SE of the large boulder. The point is a cairn on a flat rock just north of the tilted rock. Look for cairn. Consult aerial photo.

- **Point 28** - From #25, cross the river, heading back towards the road. There is a trail on the N side that goes along (upstream) the river and then turns up towards the road after a patch of cattails. Head up towards the road through another patch of cattails and look to your right. There are some fenced off areas in high grass flatland. There is a large cottonwood with a forked trunk with holes in the trunk. This is one of the largest cottonwoods in the area and it is the point. Look for cairn. Consult aerial photo.

- **Point 26** - From #28, make your way back up to the main road and walk down the canyon until you see a sign that says "Weeping Rock." From this sign, you can look towards the river and see a clearing. The point is the lone, skinny, young cottonwood in the grass about 44 meters from the road. Look for cairn. Consult aerial photo.

- **Point 21** - Keep heading down the canyon on the road. You'll cross a bridge. Point is just past that bridge on your left, up from a big, green rock, about 15 meters. Look for cairn. Consult aerial photo.

- **Point 22** - From #21, go to the South end of the bridge that you just crossed. There is a trail that leads down to the river. Take this trail until you see a couple of large cement barriers. From here, you will see a large boulder across the river under "The Organ" just before the hill gets steep. To the right of this boulder (about 50 meters), there is a downed cottonwood snag that is cracked in the center. That is the point. Look for cairn. Consult aerial photo.

- **Point 20** - From #22, head South along the ridgeline, around "The Organ," past a very large boulder with vegetation on it. About 30 meters past that boulder, look to your left. There is a tall cottonwood snag with no bark about 6 feet up the snag. That is the point. Look for cairn. Consult aerial photo.

- **Point 19** - From #20, head back to the ridgeline. Point #19 is up the ridge about 50 meters, directly even with the highest point of "The Organ." Bearing is 120 degrees from this highest point. Point is by large, tall juniper on very steep hillside. Good luck. Look for cairn. Consult aerial photo.

- **Point 18** - Head downriver until you are even with the lowest part in the saddle between "Angel's Landing" and "The Organ." You can bushwhack or walk through the river to get here. (I recommend the river.) Just after a sandbar with a calm right-hand tributary that goes by a HUGE slanted boulder, bushwhack up into the pinyon-juniper. Point is about 50 meters towards the middle of the saddle. Be careful, very steep, very thick vegetation. Point may need to be moved. Look for cairn. Consult aerial photo.

- **Point 17** - From #18, follow the river downstream until it makes a big left turn and the right side of the riverbank becomes red rock cliff. Get out of the river here and head into the cottonwood grove on your left. Find the "trail" that follows the raised left bank of the river. If you see a large wire grating or mesh, you are in the right spot. Follow this trail downstream. It passes on the left of a big cottonwood with three main trunks. The point is after that cottonwood, under the

horizontal branch of the next cottonwood behind it. Look for cairn. Consult aerial photo.

- **Point 16** – From #17, follow the trail along the bank and the row of old cottonwoods. There will be a small grove of young cottonwood and cattails. Before you pass through this grove, you will see a small faint trail leading up towards to road and to a spring. The point is on that small trail, just before the spring. Look for a silver tag marked, "ZC37." Look for cairn. Consult aerial photo.

Restoration Area: Points 1-15

Note: Aerial photos are a must for this count; GPS is not reliable in the canyon. Look for rock cairns as point markers, that is all you have to go on. Contact Park Biologist Sharon Kim for permission pass and accommodations.

(Listed in recommended count order)

Enter Zion Park main canyon; make your way up to the Grotto shuttle stop.

- **Point 15** – Within "The Grotto," find the "25 mph" and "Pedestrian crossing" sign. Sign is across road from "The Grotto," near the "Angel's Landing" trail. From this sign, walk 21 meters at 283 degrees. This is the point. Look for cairn. Consult aerial photo.

- **Point 11** – Get on main road and go down canyon about 0.5 km. On your right, about 7 meters from the road will be a large white tree lying on the ground in a field of wheatgrass. Stand on the middle of this log and walk 18 meters at 310 degrees. That is the point. Look for cairn. Consult aerial photo.

- **Point 7** – Point #7 is in Zion Lodge Parking Lot. Find the rectangular sign that says, "Emerald Pools Trail Horse Corral." It is a short sign in the West end of the parking lot. Point is 21 meters at 138 degrees from this sign. Look for cairn. Consult aerial photo.

- **Point 2** – From point #7, go down main road approx 0.5 km to a turnout on your left. See aerial photo. There are rectangular rocks of the east side of the road at the south end of this turnout. The point is the fourth, long, gray rectangular rock 1 meter from the road. Look for cairn. Consult aerial photo.

- **Point 1** – From point #2, head east towards river. You'll cross a sandy trail along the way. Point is approx. 10 meters from river. You'll see a large, old, rotted tree lying flat, half-buried in the sand. The tree is in a field of grass. The roots of this tree are the point. Look for cairn. Consult aerial photo.

- **Point 3** – From point #1, head upstream along the bank about 100 meters. You'll come to a Y-shaped dead tree, leaning up against a live tree. Point is 22 meters at 358 degrees from the Y-shaped tree on sloped riverbank. Look for cairn. Consult aerial photo.

- **Point 4** – From point #3, continue upstream about 120 meters. Look west across stream. You should see a small brick wall. Cross the stream here, climb brick wall to a trail. Follow trail upstream to a small rock cairn on left side of the trail. Go uphill and slightly left through several patches of cacti. You'll come to a large boulder. Continue up to another, larger boulder. This boulder is the point. Look for cairn. Consult aerial photo.

- **Point 6** – Go back to the trail. Continue up the trail to “Horse Trail” sign that is facing the other way (north). A little past this sign will be a fork in the trail. Take the left fork, which will switchback up the hill. After the first switchback, which turns right, go halfway up the trail before the trail switchbacks left. There will be a rock cairn on the right side of the trail. This is the point. Look for cairn. Consult aerial photo.
- **Point 5** – Follow the trail further up. It will become paved. On right side of trail, there will be three large boulders and then an even larger boulder with the letters “CC” scratched into it. This boulder is the point. Look for cairn. Consult aerial photo.
- **Point 8** - Continue up the trail, which will go down through a valley and along a steep cliff. Continue along the trail until another rock cairn on the right side of the trail. Head up the hill at 300 degrees from this cairn. Go up and left at big cactus to a twisted tree with a small cairn in front of it. Head right and up from here to a boulder with a cairn on it. This is the point. Look for cairn. Consult aerial photo.
- **Point 9** – Continue along the trail until you come to a log across the trail. This log is the point. Look for cairn. Consult aerial photo.
- **Point 10** – Turn around and go back down the trail all the way to the bridge. Cross the bridge and immediately after the bridge, turn left onto a trail. Follow this trail until you come to a dead tree that you must walk under to proceed. After you walk under the tree, walk towards the river at 300 degrees until you are approx. 12 meters from the river, where the grass meets brush. This is the point. Look for cairn. Consult aerial photo.
- **Point 12** – Continue to follow the trail that you were on, upstream, until you see the stream in front of you and a long log that leads down to the bank on your left. Make your way down this log and over to the tree by a brick wall. This is the point. Look for cairn. Consult aerial photo.
- **Point 13** – Continue up the trail, about 100 meters. Cross the river just before the shoreline starts to get bushy on your side. Go up and left to the muddy bank. Look up and there will be a tree about 20 meters from the shore that is lighter-green than the other trees on the shore. This is the point. Look for cairn. Consult aerial photo.
- **Point 14** – Go back to trail and continue up the stream about 100 meters to a large rock pile on the left side of the trail. This is the point. Look for cairn. Consult aerial photo.

**APPENDIX B. 2003 SAMPLING POINT LOCATION UTMS
(NAD27, UTM ZONE 12).**

POINT	X-COORDINATE	Y-COORDINATE	AREA
1	326321	4123896	Restoration
2	326421	4123896	Restoration
3	326321	4123996	Restoration
4	326221	4124196	Restoration
5	326121	4124396	Restoration
6	326221	4124396	Restoration
7	326421	4124496	Restoration
8	326221	4124696	Restoration
9	326321	4124796	Restoration
10	326421	4124896	Restoration
11	326621	4124896	Restoration
12	326521	4124996	Restoration
13	326521	4125096	Restoration
14	326621	4125196	Restoration
15	327008	4125453	Reference
16	327521	4126196	Reference
17	327521	4126296	Reference
18	327521	4126496	Reference
19	327721	4126596	Reference
20	327821	4126596	Reference
21	328021	4126596	Reference
22	327921	4126696	Reference
23	327321	4126796	Reference
24	327621	4126796	Reference
25	327821	4126796	Reference
26	328021	4126796	Reference
27	327421	4126896	Reference
28	327921	4126896	Reference
29	327421	4126996	Reference
30	327521	4126996	Reference

**APPENDIX C. 2003 MIST NET LOCATION UTMS
(NAD27, UTM ZONE 12)**

NET	X-COORDINATE	Y-COORDINATE	AREA
1	326431	4124805	Restoration
2	326444	4124842	Restoration
3	326448	4124920	Restoration
4	326477	4124933	Restoration
5	326503	4124977	Restoration
6	326568	4124960	Restoration
7	326461	4124990	Restoration
8	326542	4125036	Restoration
9	326552	4125094	Restoration
10	326563	4125124	Restoration
11	327968	4126683	Restoration
12	327968	4126697	Restoration
13	327969	4126720	Restoration
14	327969	4126733	Restoration
15	327801	4126985	Reference
16	327783	4126972	Reference
17	327750	4127007	Reference
18	327703	4126925	Reference
19	327565	4126862	Reference
20	327525	4126815	Reference