1996-2000 Avifauna Monitoring in Glen, Marble and Grand Canyons

John R. Spence
National Park Service
Glen Canyon National Recreation Area

Primary Field Crew

- Jim Petterson (co-PI, birds; 1996)
- John Spence (PI, birds and vegetation; 1996-2000)
- Chuck LaRue (birds; 1997-1999)
- Jennifer Holmes (birds; 1999-2000)
- Nikolle Brown (birds; 1997-2000)
- Jeanette Muller (vegetation; 1997-1999)

Many Thanks to:

- Jeff Behan and Carol Fritzinger
- >40 Bio-technicians and Volunteers
- Numerous boatmen, including in particular Brian Dierker, Kirk Burnett, and Pete Weiss
- Advice and support from Dr. Charles van Riper III, Mark Sogge, Tim Tibbitts, and Matt Johnson

Why Birds?

Advantages

- Sensitive to change, good indicators
- Easy to monitor
- Habitat specialists
- Site faithful
- Aesthetics and popularity

Disadvantages

- High annual variability
- Dam effects indirect through habitat
- Factors outside study area

Agencies Involved

- Bureau of Reclamation → USGS
  - *GCES* → *GCMRC*
- National Park Service - Glen Canyon NRA
- U.S.G.S. Colorado Plateau Field Station
- Arizona Department of Game and Fish
- U.S. Fish & Wildlife Service
- Hualapai Nation

Initial Constraints

- Artificial ecosystem below Glen Canyon Dam
- Program funded to study effects of dam operations only
- Lack of continuity in monitoring and methods
- Birds not necessarily a good “variable” to study effects of dam operations?
- Severe logistics and methodological problems
- NPS Management concerns and constraints
- Statistical power based on narrow riparian corridor and small sample sizes
- Dynamic vegetation related to past flooding

Elements of the GCMRC Riparian Bird Monitoring Program

- Breeding riparian bird baseline surveys
- Winter aquatic bird baseline surveys
- Winter terrestrial bird baseline surveys
- Riparian habitat characterization and monitoring
- Methods for future long-term monitoring
- Statistical power of monitoring program
- SWIFL monitoring

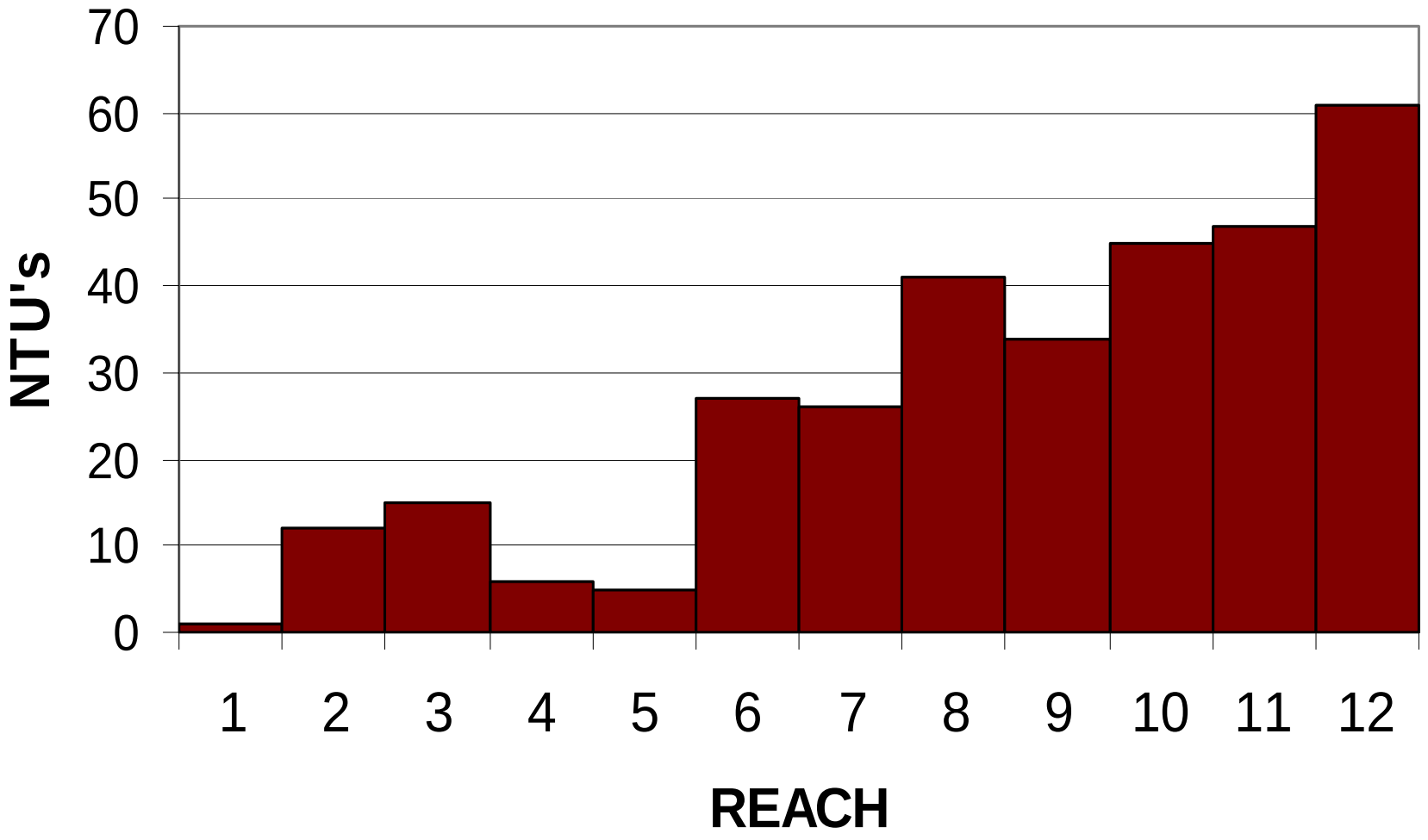
Data Sets

- 1984-1986 GCES breeding bird area surveys
- 1992-1999 Glen Canyon breeding bird point counts
- 1993-1995 USGS Monitoring methods and Research
- 1996-1999 Glen Canyon breeding bird area surveys
- 1996-2000 Grand Canyon breeding bird point counts
- 1996-1999 Grand Canyon breeding bird area surveys
- 1998-2000 Study area winter terrestrial bird area surveys
- 1991-1998 Glen Canyon aquatic bird surveys
- 1998-2000 Study area aquatic bird surveys
- 1993-1997 Upper Lake Mead breeding bird area surveys
- 1997-2000 TVV Vegetation volume

Winter Aquatic Birds

- Floating surveys from Glen Canyon Dam to Lake Mead
- Two trips per year - January and February
- Survey above Lee's Ferry the day before
- Boat operator and two bird surveyors, one recorder
- Trip from Lee's Ferry - 16 days long
- Count birds going past upriver only
- Divided river corridor into 5-km segments from -25 km (base of dam) to 390 km (Separation Canyon)
- Collected turbidity data
- Combined with winter terrestrial bird trips

TURBIDITY BY REACH



Aquatic Bird Abundance

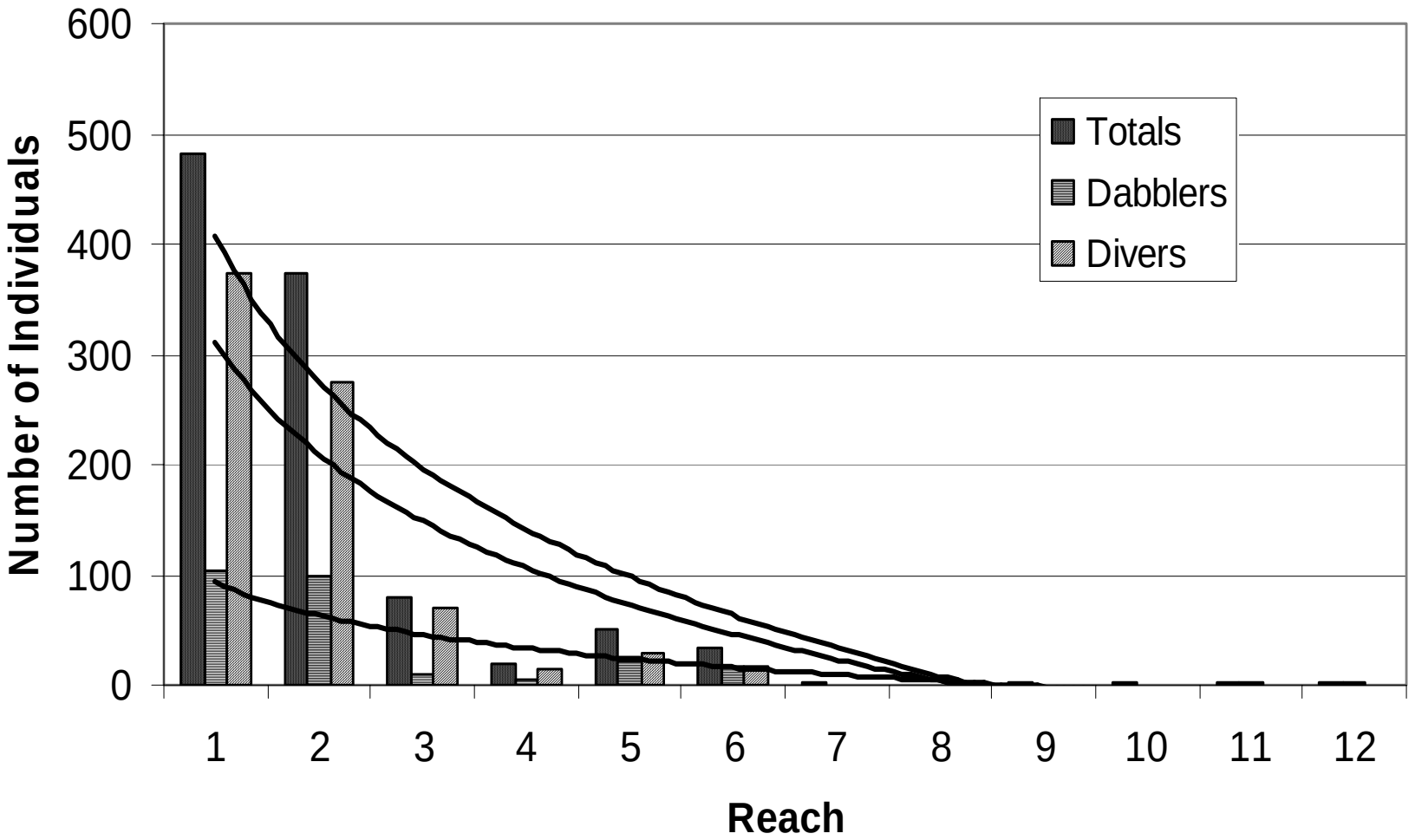


Table VI-5. Results of multiple response permutation procedure (MRPP) tests for two data sets, species composition and abundance by 5-km segment from Lee's Ferry to the Little Colorado River for 1998-2000, and species composition and abundance by 5-km segment from Glen Canyon Dam to the Little Colorado River for 1998 and 1999. The number of groups per contrast, along with both observed and expected δ's and significance values are given. January 1998 is significantly different from all three other months, while February 1998 and January 1999 are not significantly different, and February 1999 is significantly different with all three other months.

Contrast	**Number of Groups**	**Observed δ**	**Expected δ**	**P**
1998-2000 (Lees Ferry-Lake Mead)				
Years	3	72.535646	73.497768	0.0379[1]
Months	2	73.598819	73.497768	0.5081
Months X Years	6	73.240208	73.497768	0.3045
1998-1999 (Glen Canyon Dam-Lake Mead)				
Years	2	110.69750	114.26284	0.0013
Months	2	114.76440	114.26284	0.8977
Months X Years	4	111.68181	114.26284	0.0264[2]

[1]all 3 years significantly different

[2](A)January 1998>(B)February 1998=(B)January 1999>(C)February 1999

Table VI-4. Stepwise regressions of total abundance, dabbler abundance and diver abundance of winter aquatic species along the Colorado River from 1998-2000 and the combined totals. The best model, Student's T, r^2 and probability are listed for each analysis. Three variables were introduced using a backward stepwise model, mean reach area, mean reach width, and mean turbidity (NTU's) per reach.

Analysis by Year	Best Model	Student's T	r^2	p
1998				
Totals	Area + Width	$-2.89_{area} + 5.13_{width}$	0.694	$0.0178_{area} + 0.0006_{width}$
Dabblers	NTU + Width	$-3.03_{NTU} + 3.77_{width}$	0.794	$0.0143_{NTU} + 0.0044_{width}$
Divers	NTU + Width	$-3.41_{NTU} + 3.42_{width}$	0.796	$0.0077_{NTU} + 0.0076_{width}$
1999				
Totals	NTU + Width	$-2.85_{NTU} + 2.46_{width}$	0.695	$0.0190_{NTU} + 0.0363_{width}$
Dabblers	NTU + Width	$-2.56_{NTU} + 2.90_{width}$	0.708	$0.0305_{NTU} + 0.0176_{width}$
Divers	NTU + Width	$-3.00_{NTU} + 2.26_{width}$	0.692	$0.0151_{NTU} + 0.0498_{width}$
2000				
Totals	NTU + Width	$-3.11_{NTU} + 2.33_{width}$	0.707	$0.0125_{NTU} + 0.0449_{width}$
Dabblers	Width	4.98_{width}	0.684	0.0006_{width}
Divers	NTU	-4.23_{NTU}	0.606	0.0017_{NTU}
All 3 Years				
Totals	NTU + Width	$-3.13_{NTU} + 2.39_{width}$	0.714	$0.0120_{NTU} + 0.0409_{width}$
Dabblers	NTU + Width	$-2.73_{NTU} + 3.35_{width}$	0.753	$0.0233_{NTU} + 0.0085_{width}$
Divers	NTU + Width	$-3.63_{NTU} + 2.56_{width}$	0.761	$0.0055_{NTU} + 0.0309_{width}$

Winter Terrestrial Birds

- Sampled patches between Glen Canyon Dam and upper Lake Mead
- Used timed area search
- Two trips per year - January and February/18 days
- Two bird surveyors
- Surveyed between first light and ca. 1700 hrs
- Collected weather data at beginning of survey
- Selected many patches that were sampled during the breeding bird work
- Recorded habitat first detected in, behavior, sex if possible
- Combined with winter aquatic trips

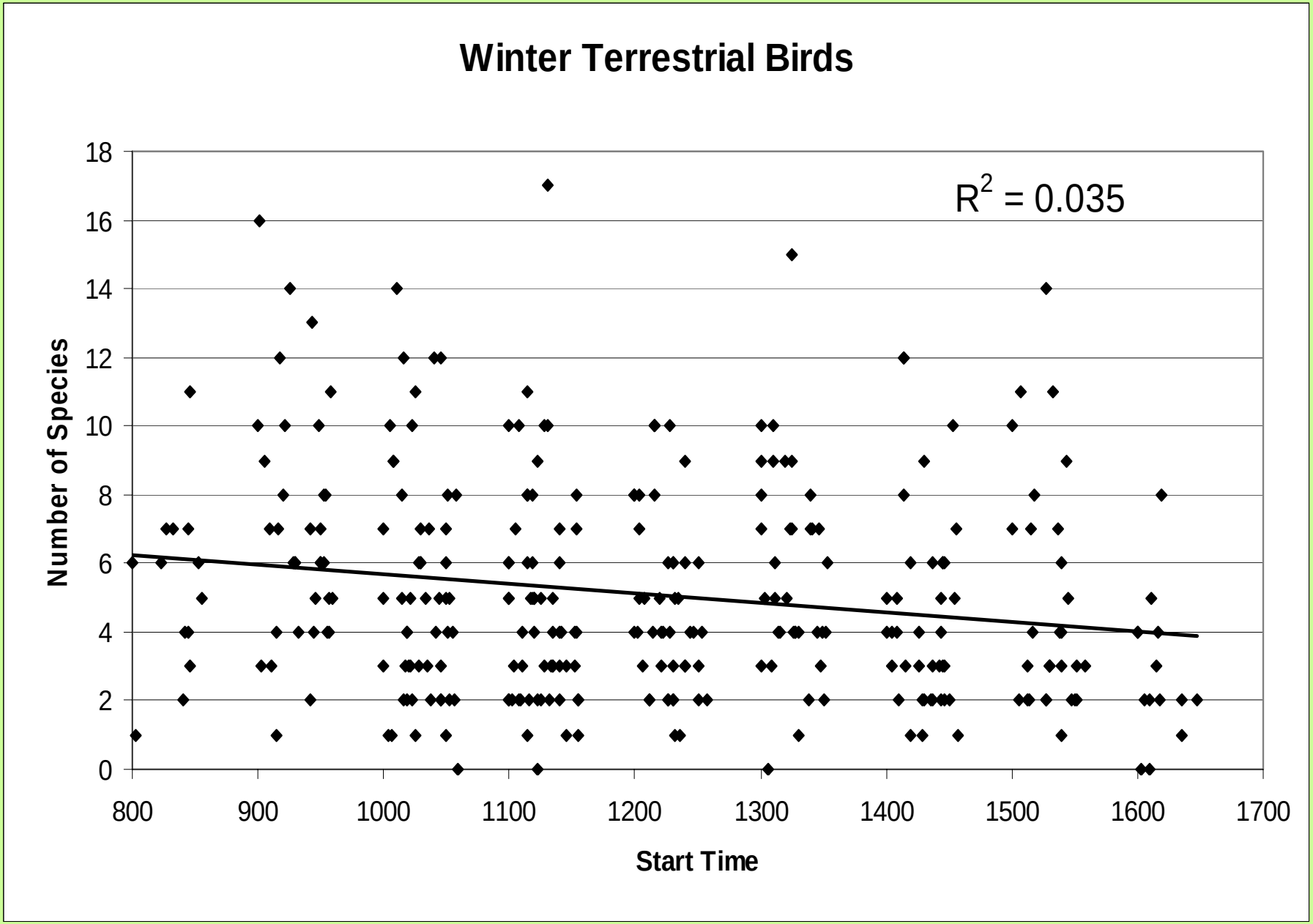
Table V-1. *The most common winter terrestrial species along the Colorado River riparian corridor for 1998-2000. Each data set is based on two trips, one each in January and February. Those species with at least 1% of the total number of birds detected in any one year are listed.*

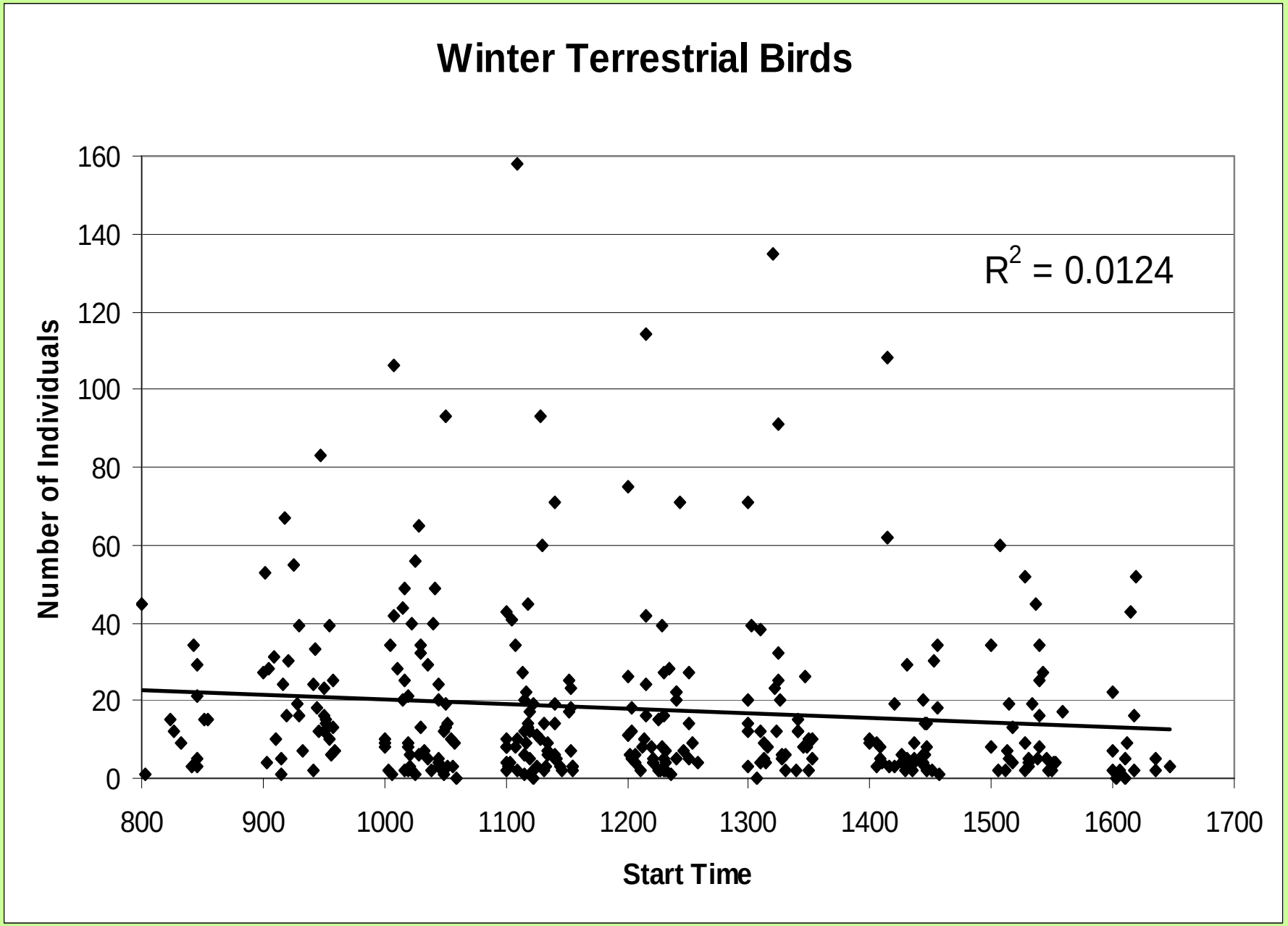
	1998		1999		2000	
Species	**Rank**	**Number**	**Rank**	**Number**	**Rank**	**Number**
White-crowned Sparrow	1	470	7	140	1	385
Ruby-crowned Kinglet	2	351	1	351	3	183
Dark-eyed Junco	3	287	2	259	10	47
Song Sparrow	4	119	6	145	4	112
Bushtit	5	116	3	180	2	380
Western Bluebird	6	115	5	168	9	52
Bewick's Wren	7	109	8	124	6	76
Pinyon Jay	8	101	11	58	15	15
House Finch	9	94	4	168	11	40
Red-winged Blackbird	10	72	-	-	-	1
Canyon Wren	11	55	9	102	8	50
Yellow-rumped Warbler	12	53	10	68	5	83
Lincoln's Sparrow	13	40	14	21	16	13
Rock Wren	14	38	12	46	14	15
Say's Phoebe	15	35	13	33	12	29
Marsh Wren	16	34	15	31	13	22
Phainopepla	-	8	12	33	17	12
Horned Lark	-	-	-	-	7	50
Patches Surveyed		**103**		**128**		**101**
Total Bird Abundance	**-**	**1939**	**-**	**2150**	**-**	**1656**
Total Species	**-**	**51**	**-**	**57**	**-**	**47**

Table V-6. The results of multiple response permutation procedure (MRPP) tests of species composition and abundance among patches between years, months within years, and months by years for the winter terrestrial avifauna between 1998-2000. The number of groups per contrast, along with both observed and expected δs and significance values are given. The 1998 data set is significantly different from 1999 and 2000, while the latter two are not different from each other.

Contrast	Number of Groups	Observed δ	Expected δ	P
Years	3	13.591727	13.685926	0.045[1]
Months	2	13.688433	13.685926	0.431
Months X Years	6	13.608159	13.685926	0.152

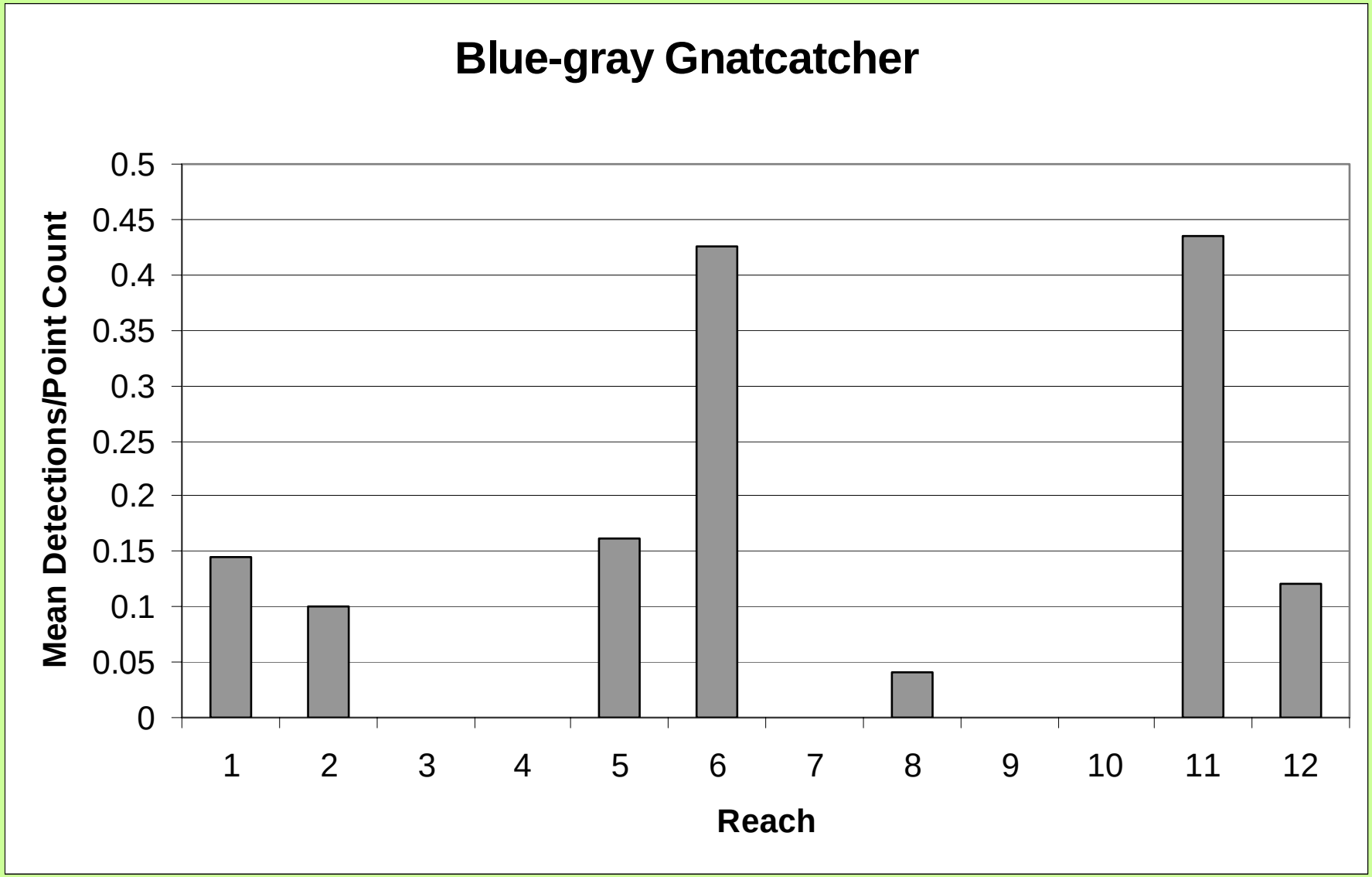
[1](A)1998>(B)1999=(B)2000

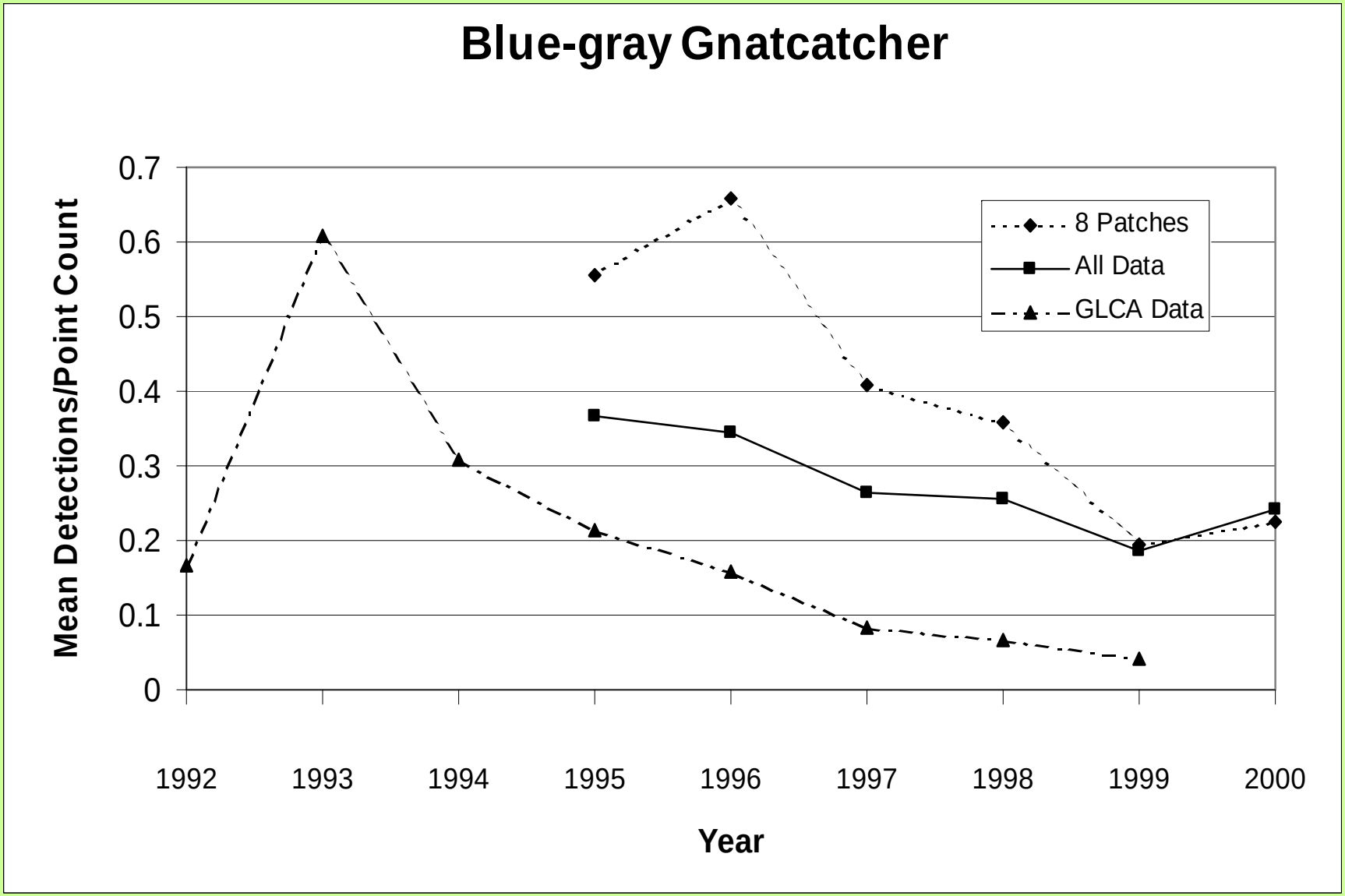

Winter Terrestrial Birds
$R^2 = 0.035$
Number of Species
0
2
4
6
8
10
12
14
16
18
800
900
1000
1100
1200
1300
1400
1500
1600
1700
Start Time


Winter Terrestrial Birds
Number of Individuals
160
140
120
100
80
60
40
20
0
800
900
1000
1100
1200
1300
1400
1500
1600
1700
Start Time
R2 = 0.0124

Breeding Riparian Birds

- Fixed-radius 50 meter point counts
- 5-minute point counts
- Timed area walking surveys
- Patch-based sampling
- 1,700 counts between 1996-2000
- Variable-radius point counts for distance and density estimation in 2000
- 1-2 motor boats, crew of two experienced bird surveyors
- Three trips/season, each two weeks long, between Glen Canyon Dam and upper Lake Mead (1996-1997) and Diamond Creek (1998-2000)
- Patches sampled along 450 km river corridor


Blue-gray Gnatcatcher
Mean Detections/Point Count
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
2
3
4
5
6
7
8
9
10
11
12
Reach


Blue-gray Gnatcatcher
Mean Detections/Point Count
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
Year
8 Patches
All Data
GLCA Data

Habitat Characterization

- Used TVV method of Mills et al. (1991) to sample vegetation "volume".
- Method records number of "hits" by live vegetation within 10 cm of pole up to 7+ meters
- Recorded "hits" by species for species-specific data for bird-habitat modeling
- Sampled 62 patches, both NHWZ and OHWZ
- Number of samples per patch related to patch size
- Tested adequacy of sampling in patches using a PC-ORD species-area algorithm and Monte Carlo simulation
- Tested power of sampling program to detect change

STATISTICAL POWER

$$POWER = 1 - \beta$$

The statistical power of a monitoring program is the statistical ability to detect change when it is occurring

Statistical Power Tests

- Used program developed by Dr. J. Gibbs (MONITOR)
- Regression approach with Monte Carlo Simulations (up to 10,000 replications)
- Species abundance and variance based on mean detection rates per patch over 1996-2000
- Set power = 0.80 ($\beta = 0.20$), and $\alpha = 0.05$
- Two-tailed test - no change over time
- 10 year projections, 3 surveys/year
- Sample of 46 consistently surveyed patches
- Varied α, test, years to monitor, and patch number to examine monitoring program parameters

Table XI-1. Results of retrospective power analyses for 16 species of riparian breeding birds based on data generated from point counts sampled between 1995-2000 in 46 patches of riparian vegetation between Glen Canyon Dam and Diamond Creek. For three species found only below Lee's Ferry, Bell's vireo, song sparrow and lesser goldfinch, data from 36 patches in the Grand Canyon was used.

Species	10%[1]	20%[2]	α=0.10[3]	Years to Sample[4]	Patches Occupied[5]	Patches Needed[6]
Lucy's Warbler	1.000	1.000	1.000	5	45	20
House Finch	0.996	1.000	0.998	7	46	15
Bewick's Wren	0.999	1.000	1.000	6	44	20
Bell's Vireo	0.996	1.000	1.000	7	29	25
Black-chinned Hummingbird	0.957	0.998	0.987	8	45	35
Ash-throated Flycatcher	0.947	0.998	0.969	9	46	30
Yellow-breasted Chat	0.904	0.995	0.956	9	41	40
Blue-gray Gnatcatcher	0.900	0.982	0.931	10	39	40
Mourning Dove	0.388	0.604	0.503	17	31	55
Blue Grosbeak	0.458	0.725	0.581	15	35	55
Common Yellowthroat	0.573	0.810	0.724	14	36	50
Yellow Warbler	0.695	0.907	0.809	12	35	50
Bullock's Oriole	0.251	0.373	0.357	28	21	55
Lesser Goldfinch	0.502	0.725	0.517	18	26	45
Song Sparrow	0.550	0.789	0.853	14	22	40
Brown-headed Cowbird	0.231	0.394	0.365	30	22	60

[1]Power to detect a 10% change over 10 years for a two-tailed test, α=0.05, 3 surveys/year
[2]Power to detect a 20% change over 10 years for a two-tailed test, α=0.05, 3 surveys/year
3Power to detect a 10% change over 10 years for a two-tailed test, α=0.10, 3 surveys/year
[4]Years needed to monitor 46 patches in order to reach a power of =0.80 to detect a 10% change for a two-tailed test, α=0.05, 3 surveys/year
[5]Number of patches where each species was detected at least once between 1995-2000
[6]Number of patches to monitor in order to reach a power of =0.80 to detect a 10% change over 10 years for a two-tailed test, α=0.05, 3 surveys/year

Table XI-2. Results of retrospective power analyses for 13 species of winter terrestrial riparian birds based on data generated from total surveys conducted between 1998-2000 in 20 patches of riparian vegetation between Glen Canyon Dam and Diamond Creek.

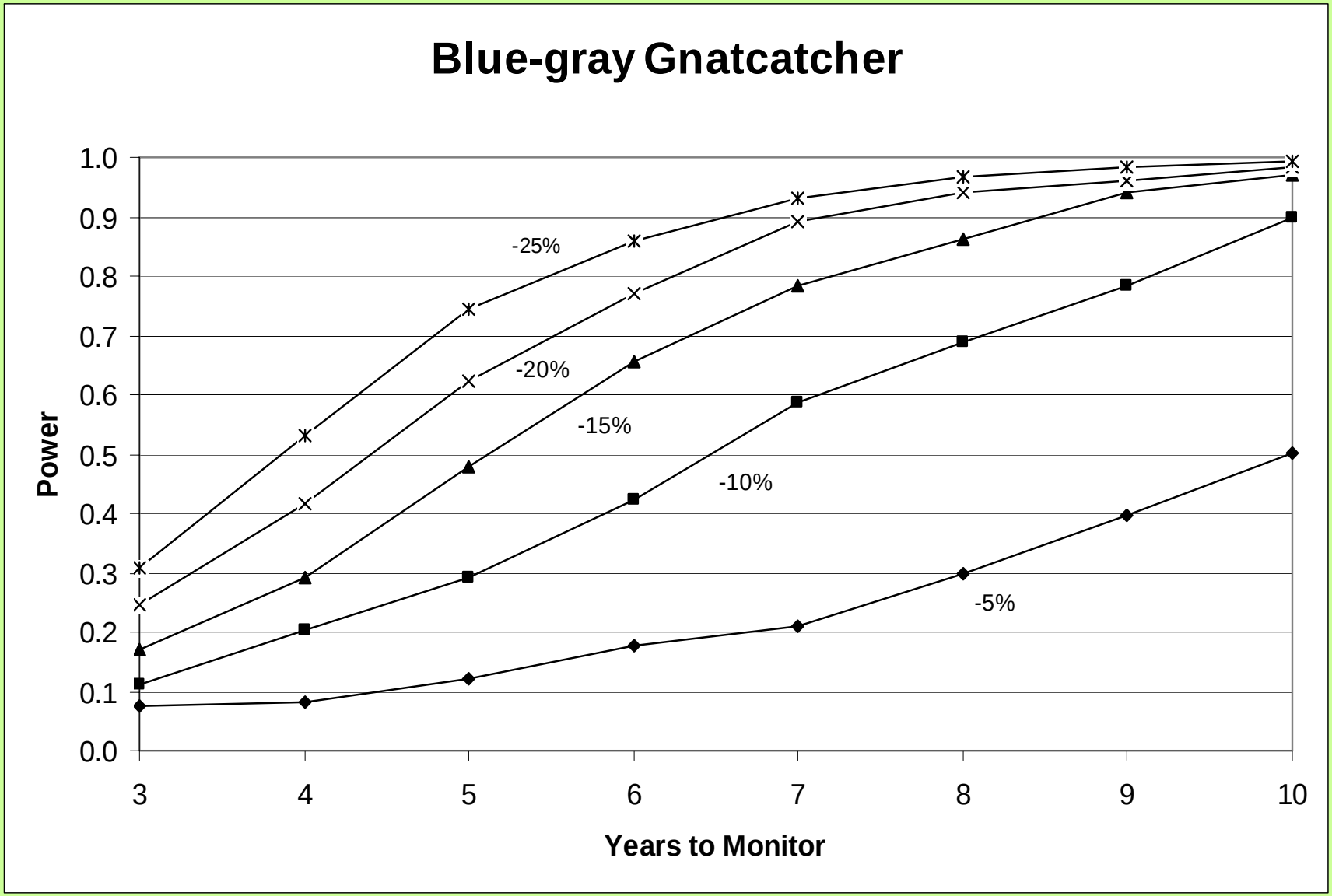
Species	10%[1]	Years to Monitor[2]	Patches to Monitor[3]	10% with 40 Patches[4]
White-crowned Sparrow	0.312	24	35	9
Ruby-crowned Kinglet	0.969	7	20	6
Dark-eyed Junco	0.325	23	45	12
Song Sparrow	0.902	9	20	6
Bushtit	0.416	18	45	11
Bewick's Wren	0.812	10	20	7
House Finch	0.253	30	40	10
Canyon Wren	0.863	10	20	6
Yellow-rumped Warbler	0.288	33	38	10
Rock Wren	0.661	13	25	6
Lincoln's Sparrow	0.382	20	28	7
Say's Phoebe	0.544	20	29	7
Marsh Wren	0.283	>50	27	7

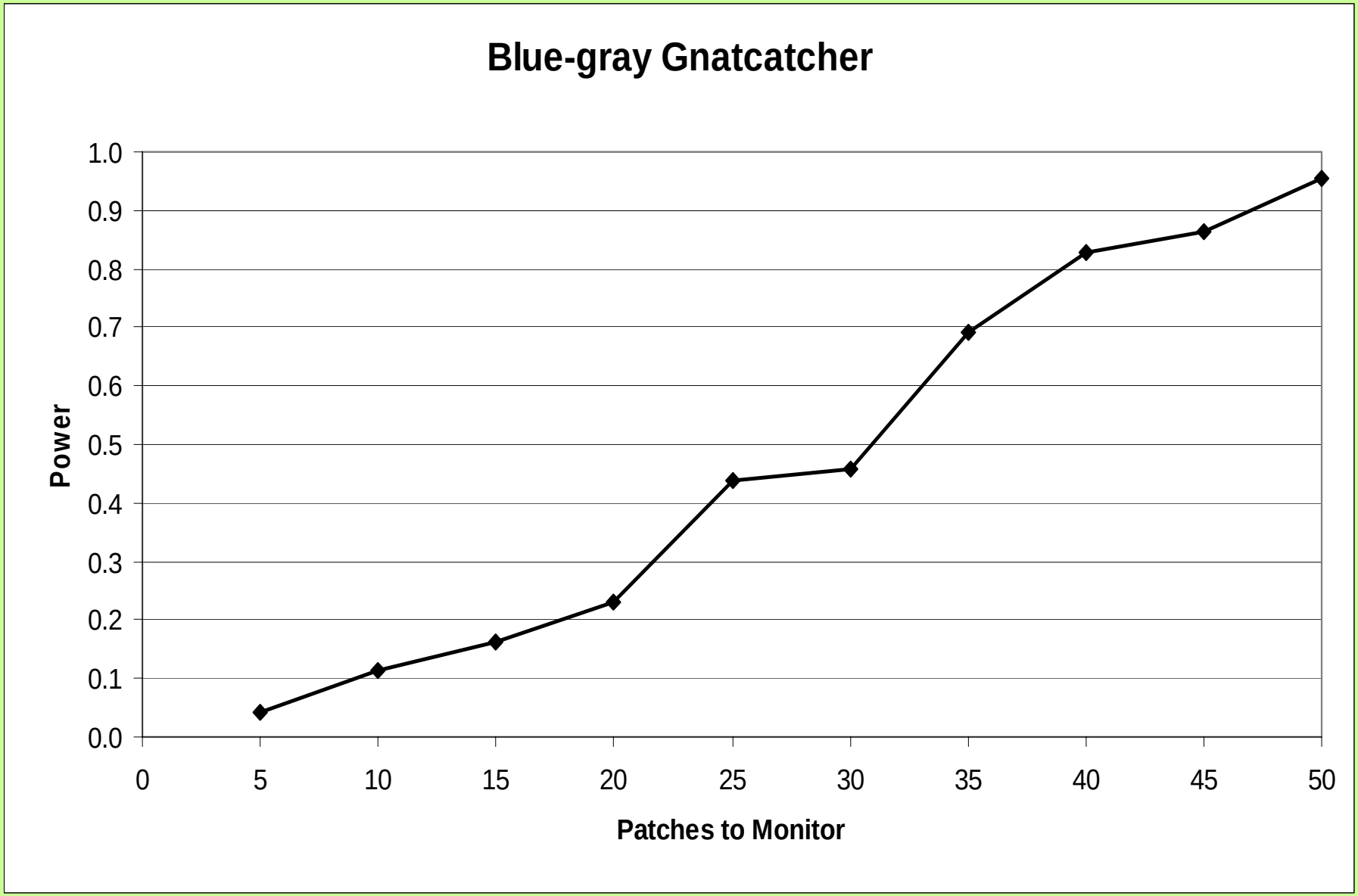
[1]Power to detect a 10% change over 10 years for a two-tailed test, α=0.10, 2 surveys/year

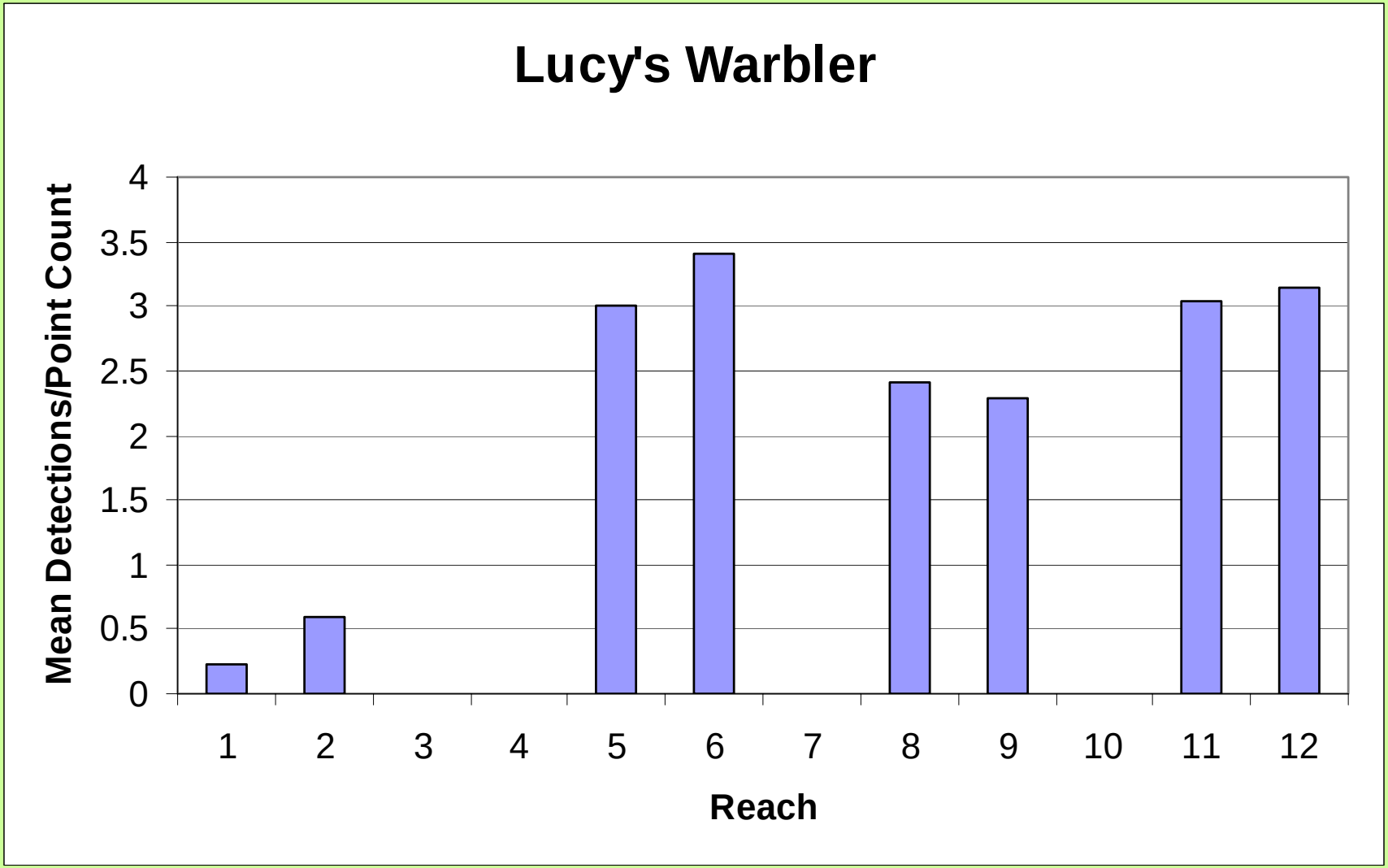
[2]Years needed to monitor 20 patches in order to reach a power of =0.80 to detect a 10% change for a two-tailed test, α=0.10, 2 surveys/year

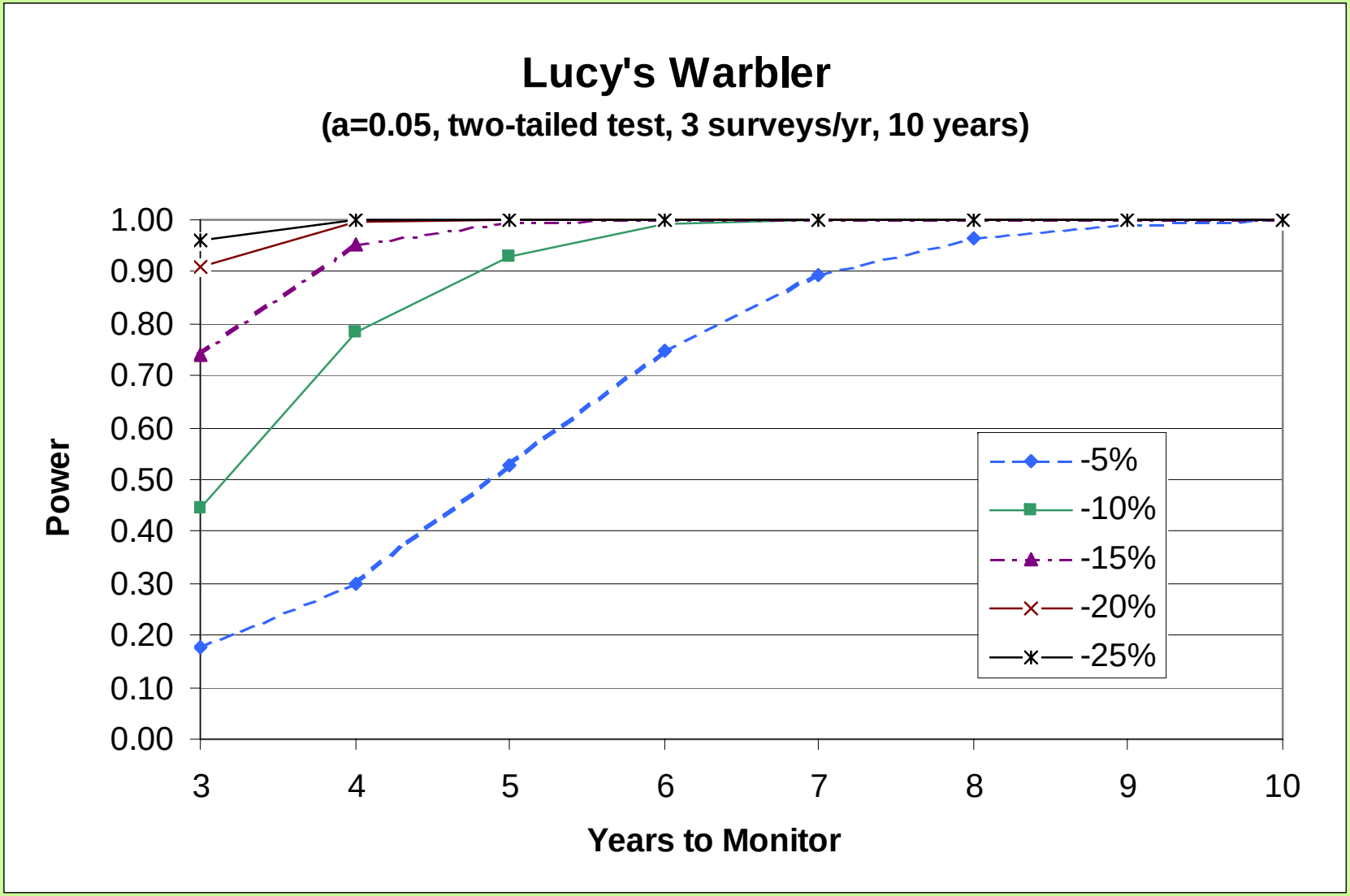
[3]Number of patches to monitor in order to reach a power of =0.80 to detect a 10% change over 10 years for a two-tailed test, α=0.10, 2 surveys/year

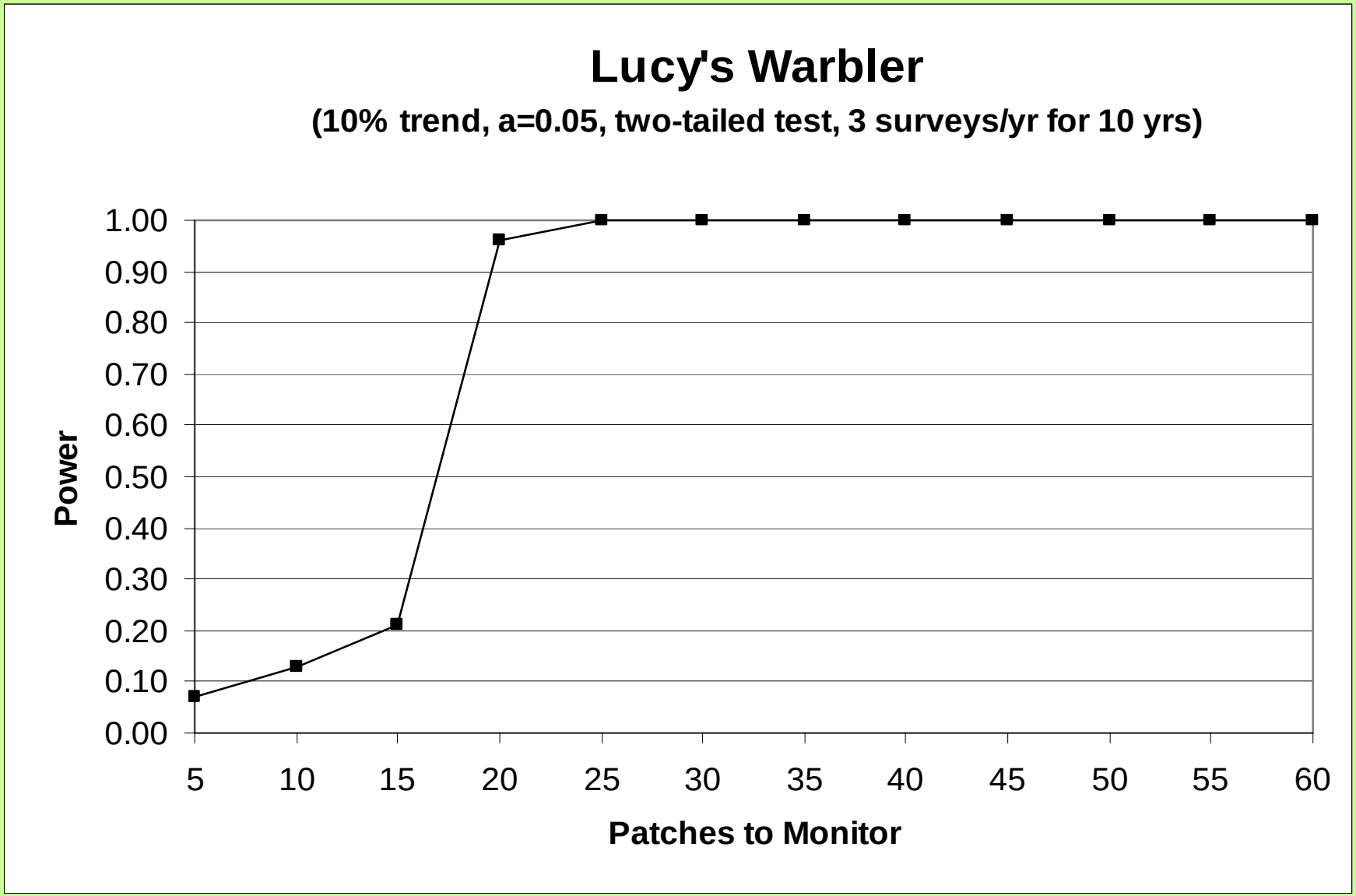
[4]Number of years to reach power of =0.80 with 40 patches sampled, two-tailed test, α=0.10, 2 surveys/year

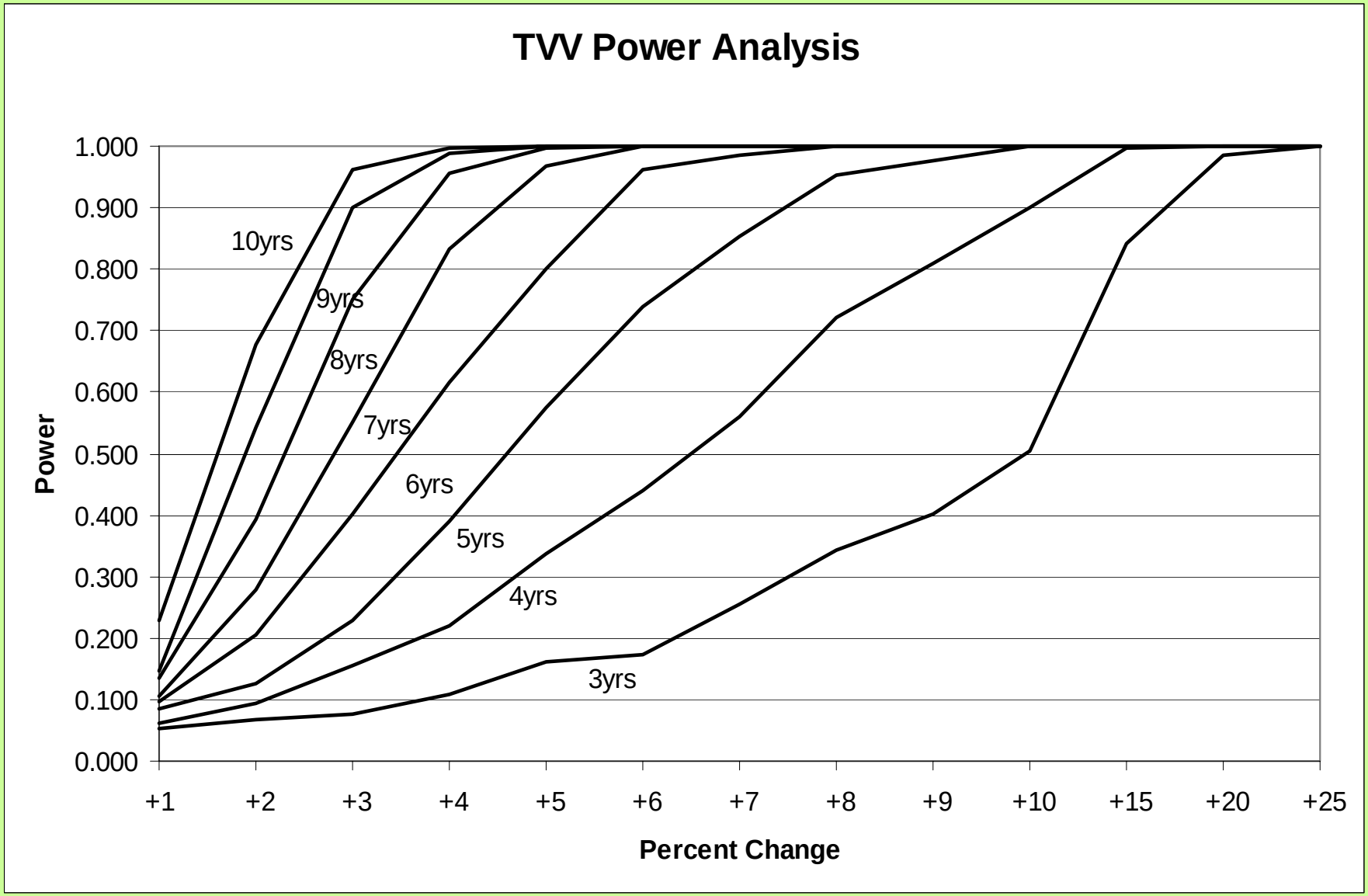

Blue-gray Gnatcatcher
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Power
-25%
-20%
-15%
-10%
-5%
3
4
5
6
7
8
9
10
Years to Monitor


Blue-gray Gnatcatcher
Power
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
35
40
45
50
Patches to Monitor


Lucy's Warbler
Mean Detections/Point Count
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
10
11
12
Reach


Lucy's Warbler
(a=0.05, two-tailed test, 3 surveys/yr, 10 years)
Power
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
3
4
5
6
7
8
9
10
Years to Monitor
-5%
-10%
-15%
-20%
-25%


Lucy's Warbler
(10% trend, a=0.05, two-tailed test, 3 surveys/yr for 10 yrs)
Power
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
5
10
15
20
25
30
35
40
45
50
55
60
Patches to Monitor


TVV Power Analysis
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Power
10yrs
9yrs
8yrs
7yrs
6yrs
5yrs
4yrs
3yrs
+1
+2
+3
+4
+5
+6
+7
+8
+9
+10
+15
+20
+25
Percent Change

2000 Distance Estimation Study

- Lee's Ferry to Diamond Creek-three trips
- Estimated distance to each sighting using range finder
- Two observers, calibrated daily
- *Problems include:*
- 1996 study design violates distance estimation assumptions
- Study area heterogeneous in reach, within patch in habitat and bird variables
- Only three species common enough (Lucy's warbler, Bell's vireo, Bewick's wren; probably also House finch)

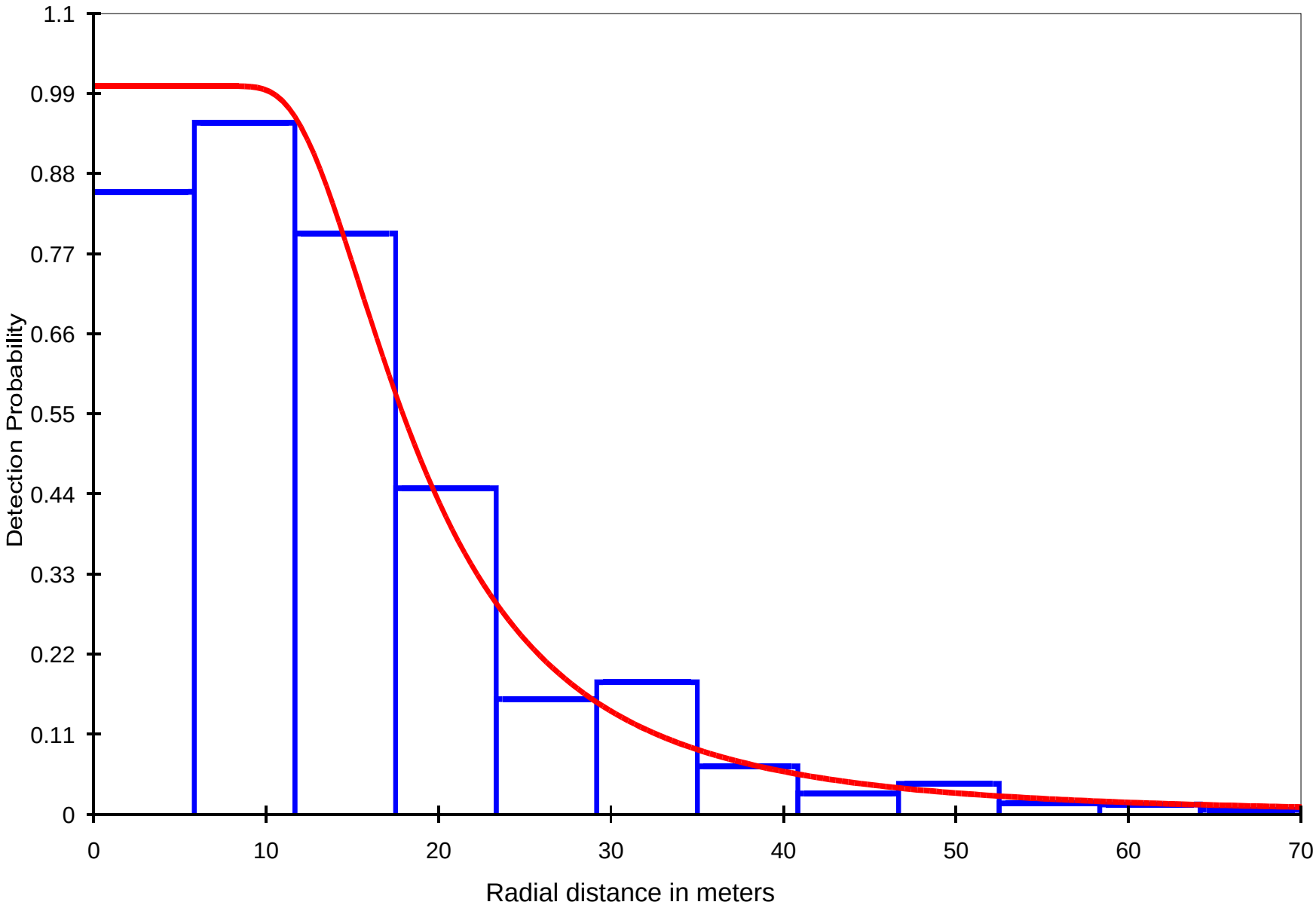

1.1
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0
Detection Probability
0
10
20
30
40
50
60
70
Radial distance in meters

Table 1. Results of analyses of BEVI distance data. The models listed include the combination of Key Function and the Adjustment Term used for each analysis.

Model	X^2 **(df)**	**p-value**	**AIC**	**Density Estimate**	**Log-based 95% confidence interval**	**% Coef. of Variation**
Hazard Rate Simple Polynomial	5.71 (8)	0.68	513.47	14.03	9.45 - 20.82	20.2
Hazard Rate Cosine	5.71 (8)	0.68	513.47	14.03	9.45 - 20.82	20.2
Half-normal Cosine	6.38 (8)	0.61	514.33	16.82	12.02 - 23.52	17.1
Uniform Cosine	6.27 (7)	0.58	516.46	14.43	10.68 - 19.50	15.3
Half-normal Hermite	15.79 (8)	0.05	522.70	11.61	8.54 - 15.77	15.6
Uniform Simple Polynomial	19.86 (7)	0.01	531.46	9.194	6.78 – 12.46	15.4

CONCLUSIONS

- We have lots of "monitoring" data
- There are significant differences within the study area
- Birds in the study area are not generally directly affected by routine dam operations
- There are large year-to-year differences for many species
- There is predictable "structure" in the bird communities
- Birds are affected by factors outside the study area
- Basic research is still needed to answer many questions
- There is adequate power to monitor some species
- Habitat data can be related to bird communities
- Habitat monitoring has good statistical power
- "Long-term" means at least 10 years of monitoring
- Some previous studies lack sufficient sample sizes for valid comparisons
- Baseline data may be inadequate to characterize background variability

RECOMMENDATIONS

- Decide if birds are a "core variable"
- Determine NPS vs. GCMRC responsibilities
  - T&E Species
- Research Needs:
  - Nesting and reproductive success
  - Foraging ecology
  - Density Estimates
- Group Data into "Guilds" (cf. *NRC 1999*)
- Develop appropriate experimental design and protocols
- Focus on Species of Special Concern
  - *Lucy's Warbler*
  - *Bell's Vireo*
- Develop Quantified Goals and Thresholds

Lessons for Regional IBM?

- Riparian corridors have peculiar problems
- It may be difficult to get good power without expanding the scope of monitoring
- Colorado River and tributaries can be linked into a drainage-wide riparian and aquatic monitoring program
- Differences between "segments" of the river system may confound explanation of composition and trends (i.e., the study area is not uniform)
- Entire drainage-level statistically valid monitoring program can be done, but complex!