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POWER OF THE MAPS PROGRAM TO DETECT DIFFERENCES AND TRENDS IN SURVIVAL AND A VISION FOR PROGRAM EXPANSION[1]

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Abstract. A major goal of the Monitoring Avian Productivity and Survivorship (MAPS) program is to provide information on spatial and temporal variation in vital rates of North American landbirds. Here we identify landbird species for which the MAPS program could likely detect differences or trends in adult apparent survival rates with 80% statistical power (α = 0.10 or 0.20) and 20 years of data based on MAPS survival-rate and recapture probability estimates, sample sizes typical of the current (2001) MAPS program, and results of power analyses applied to simulated capture-recapture data. We summarize numbers of species for which the MAPS program could likely detect differences or trends in survival at continental, MAPS-regional, and "cluster" (six-station) scales. We suggest that differences or trends in survival of ≤ 25% would be detectable (1 - β = 0.80 and α = 0.20) for 105 species at the continental scale, and for 19 (Alaska/Boreal Canada Region) to 47 species (Northwest Region) at the MAPS-regional scale. A cluster-scale analysis of MAPS stations on Pacific Northwest national forests suggested that at least 15 species could be effectively monitored at that scale. We estimate that, through targeted enhancement and expansion of the MAPS program (increasing its size by 69%), an additional 41 species could be adequately monitored at the continental scale, and 16 (Northwest Region) to 27 (South-central Region) additional species could be adequately monitored at MAPS-regional scales. We provide lists of species that MAPS currently monitors (and could potentially monitor) effectively at those two spatial scales, show that coverage is widespread for most major non-grassland habitat types, and suggest that coverage of chaparral/sagebrush shrubsteppe, boreal conifer, and boreal hardwood habitats could be improved through targeted enhancement of MAPS.
Key words: Cormack-Jolly-Seber models, demographic monitoring, landbirds, MAPS program, power analysis, survival rate estimation, trends.

PODER DEL PROGRAMA MAPS PARA DETECTAR DIFERENCIAS Y TENDENCIAS EN SOBREVIVENCIA Y UNA VISION PARA LA EXPANSION DEL PROGRAMA

Resumen. Una meta principal del programa MAPS es aportar información sobre variación espacial y temporal en tasas vitales en aves terrestres de Norteamérica. Aquí identificamos especies de aves terrestres para las que el programa MAPS podría detectar diferencias o tendencias en tasas de sobrevivencia aparente de adultos con un poder estadístico del 80% (α = 0.10 ó 0.20) y 20 años de datos basados en las estimas de tasa de sobrevivencia y probabilidad de recaptura de MAPS, y resultados del análisis de poder aplicado a datos simulados de captura-recaptura. Resumimos las especies

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para las que el programa MAPS podría detectar diferencias o tendencias en sobrevivencia a escalas continentales, regiones MAPS, y "racimos" de seis estaciones. Sugerimos que las diferencias o tendencias de sobrevivencia de ≤ 25% serían detectables (1 - β = 0.80 y α = 0.20) para 105 especies a escala continental, y para 19 (Región Alaska/Canadá Boreal) a 47 especies (Región Noroeste) a la escala de las regiones MAPS. Un análisis a la escala de racimos en los bosques nacionales del Noroeste Pacífico sugiere que al menos 15 especies podrían ser monitoreadas a esa escala. Estimamos que, mediante el aumento selectivo y expansión del programa MAPS (aumentando su tamaño un 69%), 41 especies adicionales podrían ser adecuadamente monitoreadas a la escala continental, y 16 (Región Noroeste) a 27 (Región Centro-sur) especies adicionales podrían ser monitoreadas a escala de las regiones MAPS. Aportamos listas de especies que el programa MAPS monitorea efectivamente en la actualidad a esas dos escalas, mostramos que la cobertura es amplia para la mayoría de hábitats no relacionados con praderas, y mostramos que la cobertura de los hábitats estepa arbustiva/chaparral, conífera boreal y latifoliadas boreales podrían ser mejoradas mediante aumentos selectivos de MAPS.

Palabras clave: modelos Cormack-Jolly-Seber, monitoreo demográfico, aves terrestres, programa MAPS, análisis de poder, estimación de tasas de sobrevivencia, tendencias.

INTRODUCTION

The Monitoring Avian Productivity and Survivorship (MAPS) program was established in 1989 to monitor primary demographic parameters (vital rates) of landbirds in North America (DeSante 1992), to use those data to identify the proximate demographic cause(s) of population declines (DeSante et al. 2001, Saracco et al. 2008), and to formulate and evaluate management actions and conservation strategies to reverse those declines (DeSante and Rosenberg 1998, DeSante et al. 2005). The MAPS program consists of a cooperative continental-scale network of mist-netting and bird-banding stations operated each summer. The highest densities of stations occur towards the coasts (where human population densities are greater) and within the lower 48 U.S. states (Fig. 1). Many MAPS stations (227 or about 25% of all stations that have ever registered with the program) are long-running stations, having operated for ≥ 10 years. MAPS uses a standardized "constant-effort" protocol to provide estimates or indices of a broad suite of population parameters (Saracco et al. 2008, DeSante and Kaschube 2009). MAPS complements efforts that focus on abundance and trend estimation (e.g., the North American Breeding Bird Survey [BBS]), and could fill an important niche in the developing North American Coordinated Bird Monitoring (CBM) program (Coordinated Bird Monitoring Working Group 2004, Bart 2005, Bart and Ralph 2005).

Among the principal metrics monitored by MAPS is the annual apparent survival rate of adult birds (hereafter "survival"). Survival can be estimated at spatial scales ranging from single banding stations (occasionally), through local clusters of banding stations, to regional and continent-wide scales (Rosenberg et al. 1999, 2000). Here we identify species for which the MAPS program could likely detect trends or differences in adult apparent survival rates with 80% statistical power (α = 0.10 or 0.20) and 20 years of data based on MAPS survival-rate and recapture probability estimates, sample sizes typical of the current (2001) program, and results of power analyses applied to simulated capture-recapture data (DeSante et al. 2009a). We summarize numbers of species for which the program could likely detect differences or trends in survival at continental, MAPS-regional (DeSante et al. 1993), and "cluster" (six-station) scales. We list species that are "adequately" monitored across a range of effect sizes at continental and MAPS-regional scales. In addition to assessing the current program, we suggest a strategy for expanding MAPS, so that it can contribute optimally to a continental-scale CBM effort. We report improvements in the ability to detect smaller effect sizes under such expansion, as well as a list of additional species that could be monitored with MAPS methodology.

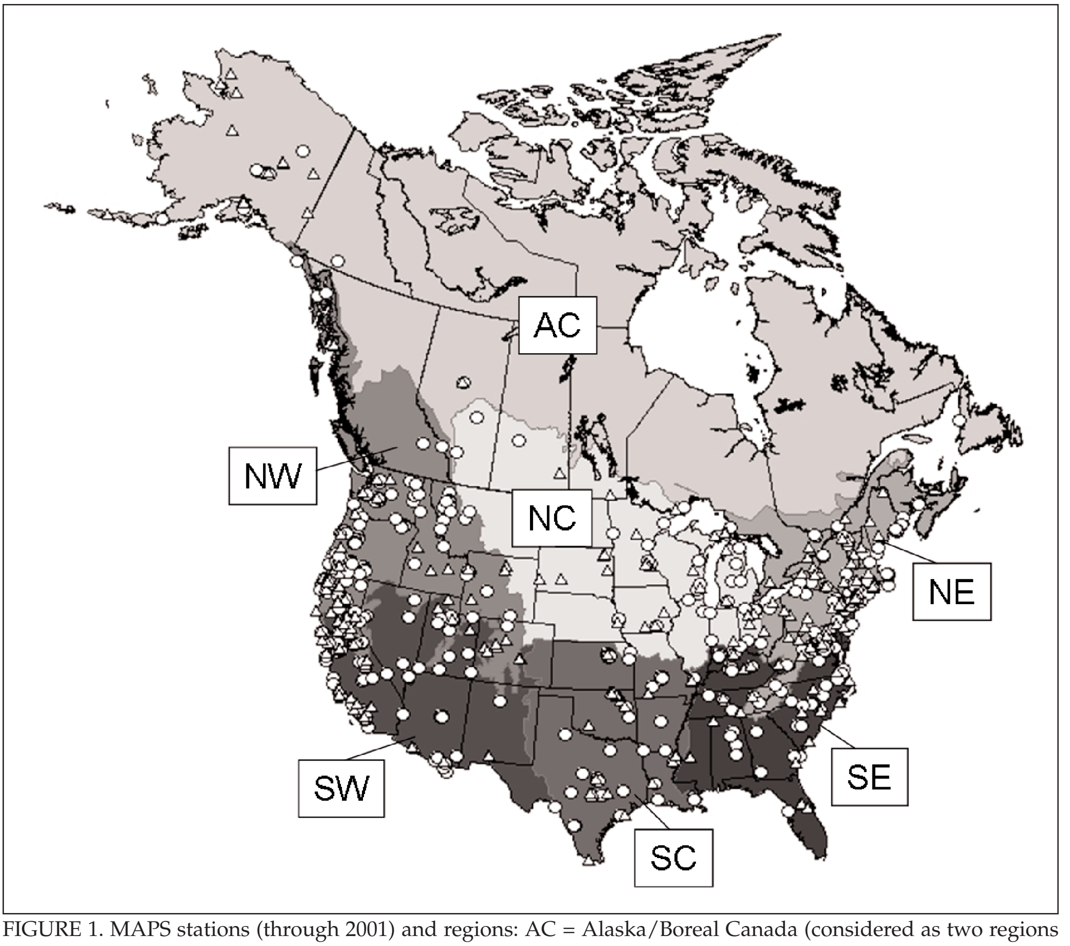

FIGURE 1. MAPS stations (through 2001) and regions: AC = Alaska/Boreal Canada (considered as two regions by DeSante 1992), NW = Northwest, NC = North-central, NE = Northeast, SW = Southwest, SC = South-central, and SE = Southeast. Stations still operating in 2001 are indicated by open circles; those established and operated, but that stopped prior to 2001, are indicated by open triangles.

METHODS

The MAPS program is a cooperative network of constant-effort mist-netting stations operated during the breeding season (May to August) across the United States and southern Canada. DeSante and Kaschube (2009) provide an overview of the design and operation of the program; detailed protocols for establishing and operating MAPS stations are provided in DeSante et al. (2009b) and can be found at 2009 MAPS Manual. Over 1,000 MAPS stations have been operated for at least one year since the program's inception in 1989 and over 450 stations were operated annually during the latter part of the 10-yr period (1992-2001) used in the analyses presented here. Stations were established in 20-ha study areas where long-term mist netting was permissible and practical. In general, the locations of MAPS stations were chosen by station operators (often according to a hypothesis-driven strategy) and not by a probabilistic sampling design, although elements of a random sampling strategy were sometimes employed.

We assessed the ability of MAPS to detect with 80% power (i.e., $1 - \beta = 0.80$) (1) differences in survival between two populations and (2) trends in survival for a single population. We report results for two alpha-levels (0.10 and 0.20) reported by other studies that have evaluated power of monitoring data (e.g., Bart et al. 2004). We considered five effect sizes ranging from 5 to 25%. For the two-population scenario (1 above), effect sizes represent differences in survival between two populations that begin with equal population sizes. For the linear decline scenario (2 above), effect sizes represent incremental proportional changes in survival that would halve the population in the same number of years as a population whose survival initially declined by that effect size and then remained constant. Our calculations assume initially stable populations (i.e., $\lambda = 1$) and constant recruitment at a level that balances losses at the start of the study. Although the larger effect sizes considered here could (potentially) halve populations over short time intervals (see DeSante et al. 2009a), differences in survival rates of this magnitude are typically observed in MAPS data. For example, the largest effect size (25%) is similar to the mean maximum difference in survival rates between MAPS regions for 89 species for which we were able to obtain 10-yr time-constant estimates of survival in multiple regions (mean maximum difference = 23%; DeSante and Kaschube 2006).

We assessed whether a species was captured in sufficient numbers to reject null hypotheses (no difference between populations or no change in a population) at program-wide (i.e., continental) and MAPS-regional scales (see Fig. 1 for regional boundaries) based on (1) their current sample sizes (see below for detail), (2) the magnitude of their 10-yr "time-constant" adult apparent survival and recapture probability estimates, and (3) the predicted sample sizes needed to reject hypotheses from analyses of 20 yr of data simulated from populations with similar survival and recapture probability estimates (see DeSante et al. 2009a for more detail). We simulated capture-mark-recapture data sets of various sizes using the deterministic mode of program GENCAPH1 (www.mbr-pwrc.usgs.gov/software.html) for 20 capture periods (i.e., years for estimates of annual survival). For all sets of simulations we chose an initial sample size of 10 individual marked animals released per year. We repeated this process for a series of sample sizes ranging from 20-2000 annual releases of marked animals. We input simulated capture histories into Program MARK (White and Burnham 1999) and estimated survival with Cormack-Jolly-Seber (CJS) models.

Each species was binned according to its survival and recapture probability estimate at each spatial scale (see Table 1 for bin ranges and for the number of species in each bin at the continent-wide scale). We then determined, for each species, whether current sample sizes were ≥ the number of individuals needed to detect a given effect size as based on simulation results using the survival and recapture probabilities for the bin in which the species was placed.

We also estimated the numbers of species that MAPS samples in sufficient numbers to detect differences in survival among "clusters" of six stations on six national forests in Oregon and

TABLE 1. Combinations of apparent survival and recapture probabilities within which bird species were binned according to 10-yr time-constant parameter estimates from the MAPS program. Here we indicate numbers of species that fell within each of these bins at the program-wide (continental) scale.

Survival (ϕ)	Recapture (p)						
	0.05 (0.000-0.125)	0.20 (0.125-0.275)	0.35 (0.275-0.425)	0.50 (0.425-0.575)	0.65 (0.575-0.725)	0.80 (0.725-0.875)	Total
0.20 (0.15-0.25)	1	2	1	1	0	0	5
0.30 (0.25-0.35)	1	6	3	1	1	2	14
0.40 (0.35-0.45)	4	14	5	13	2	1	39
0.50 (0.45-0.55)	3	12	37	19	7	1	79
0.60 (0.55-0.65)	7	7	9	3	1	0	27
0.70 (0.65-0.75)	4	5	4	0	0	0	13
0.80 (0.75-0.85)	0	1	1	0	0	0	2
Total	20	47	60	37	11	4	179

Washington. MAPS stations are often set up in this manner (clusters of six) on particular landholdings (e.g., a national park, national forest, or military installation) for logistical reasons, as a team of two banders can operate six stations in each 10-d period, even accounting for 2-3 days of rain.

Current sample size at each spatial scale (for each species) was determined by estimating the number of marked resident birds of each species released per year under a stable MAPS program at its current (2001) level of effort. To obtain these estimates, we first estimated the proportions of resident birds among newly-banded adult birds of unknown residency status (i.e., birds caught once in the season in which they were banded or birds caught more than once but not ≥7 d after banding) in the 10-yr (1992-2001) data set using time-constant *ad hoc* Robust Design models (Nott and DeSante 2002, Hines et al. 2003). We multiplied these proportions by the numbers of unknown-status birds in the data set and then added to these the numbers of known residents (i.e., birds recaptured ≥7 d after banding in their initial year of capture). Although these totals could simply be divided by 10 (for the 10 years in the data set) to obtain estimates of the mean numbers of birds released annually by MAPS, such estimates would underestimate current MAPS sample sizes because the program grew rapidly during 1992-1997 (from 179 to 459 stations). MAPS remained relatively constant in size from 1997 through 2001 (with an annual mean of about 478 stations), and we multiplied our estimated total numbers of resident birds by an inflation factor to reflect this stable MAPS program prior to obtaining per-year averages.

We determined inflation factors for each region and at the continental scale through a two-step process. First we calculated the proportion of stations that were usable for survival analyses (i.e., that were operated for four consecutive years) for each of the ten years 1992-2001. These proportions increased during the first three years 1992-1994 (because all stations that stopped operating during those years could not be included in survival analyses), stayed constant during the middle years 1995-1998 (at the stable proportion of stations that operated for at least four consecutive years), and decreased during the final three years 1999-2001 (because all stations that started operating during any of those three years could not be included in survival analyses). We then multiplied the number of stations operated in each of the final three years of the 10-yr time period (1999-2001) by the mean proportion of stations usable for survival analyses during the middle years (1995-1998) to estimate the number of stations that would be usable for survival analyses during each of those final three years in an on-going MAPS program.

In the second step in our inflation factor calculations, we summed the number of stations usable for survival analyses during the stable latter half of the 10-yr period (i.e., the actual numbers of usable stations during 1997 and 1998 plus the estimated numbers of usable stations during 1999, 2000, and 2001), and multiplied this sum by 2 to estimate the number of station-years useable for survival analyses over any 10-yr period of the current-sized MAPS Program. Finally, we divided this number by the actual number of station-years useable for survival analyses during 1992-2001 to provide the appropriate inflation factor. The continental-scale inflation factor was 1.30, while regional inflation factors ranged from 1.13 for Alaska/Boreal Canada to 1.67 for the Southwest (regional mean = 1.30).

Finally, we classified each species "adequately" monitored in each MAPS region into one or more of 14 major landbird habitat types found across North America, north of Mexico (Table 2). We excluded grassland and tundra habitats because MAPS field protocol (operation of about 10 fixed-location mist nets) does not effectively sample the landbirds of those habitats.

EVALUATION OF AN EXPANDED MAPS PROGRAM

The Northwest Region currently hosts the largest number of MAPS stations, with 128 stations operated annually with data usable for survival analyses (i.e., stations operated for ≥4 yr). The Southeast, Southwest, and Northeast regions each host about half the number of stations as the Northwest (70, 66, and 65, respectively). We suggest that 20 additional stations could be established and maintained in the Northwest Region, and that the number of stations in the Southwest, Southeast, and

TABLE 2. Major landbird habitat types used in this study.

Habitat type (code)	MAPS Regions	Description
Scrub/successional/ disturbed (SSD)	NW, SW, NC, SC, NE, SE, and AK&BC	Includes wet meadows in forested habitats and marshy areas in shrubsteppe habitats as well as areas modified by human disturbance, but excludes extensive areas of chaparral or shrubsteppe habitat
Pacific Northwest coniferous forest (PNC)	NW	Includes forests generally dominated by spruces, cedars hemlocks, and firs, but can include some pines and a limited hardwood component
Western coniferous forest (WC)	NW and SW	Includes forests generally dominated by pines, but can include substantial amounts of firs and a limited hardwood component
Western oak or juniper woodland (OJW)	NW and SW	Includes relatively open-canopy oak woodland and, away from the Pacific slope, open juniper, pinyon-juniper, or mountain mahogany woodland
Western riparian forest (WR)	NW and SW	Includes relatively extensive riparian areas generally dominated by willows and cottonwoods, often embedded in shrubsteppe or grassland habitat; does not include narrow riparian strips in forest or woodland habitat
Chaparral/sagebrush shrub-steppe (CSS)	NW and SW	Includes generally extensive areas dominated by woody shrubs, such as California coastal scrub, chaparral, and sagebrush shrubsteppe; does not include montane chaparral intermixed with western coniferous forest
Desert scrub (DS)	SW	Includes generally extensive areas dominated by relatively widely spaced woody or cactus vegetation
Eastern northern coniferous forest (NC)	NC and NE	Includes forests generally dominated by red spruce and balsam fir, sometimes with a limited jack pine or hardwood component
Eastern northern hardwood forest (NH)	NC, SC, NE, and SE	Includes forests generally dominated by maple, beech, and yellow birch, often with a coniferous component of white pine and hemlock
Eastern southern hardwood forest (SH)	NC, SC, NE, and SE	Includes both upland and bottomland forests generally dominated by oak, hickory, maple, cherry, tulip-poplar, or sweet gum, sometimes with a coniferous component of upland pine or bottomland bald cypress
Eastern southern coniferous forest (SC)	SC, NE, and SE	Includes southern pine savannah and pine forest, often mixed with a hardwood component of oak or hickory
Southern broadleaf evergreen forest (SBE)	SC	Includes live oak forests and woodland, as well as semi-tropical hammocks of southern Florida and brushlands of southern Texas
Boreal coniferous forest (BC)	AK&BC	Includes both upland and flooded forest dominated by spruces and tamaracks, often with a limited hardwood component of birches
Boreal hardwood forest (BH)	AK&BC	Includes relatively extensive closed birch forests as well as open aspen parklands

Northeast regions could be increased to the current effort in the Northwest. The South-central, North-central, and Alaska/Boreal Canada regions have fewer stations still, with 50, 32, and 22 stations, respectively, operated annually with data suitable for survival analyses. We suggest that the numbers of stations in these remaining regions, which have considerably smaller human population densities, more grassland habitat (unfavorable for passive mist netting), or both, be increased to the average current level of coverage in the Southwest, Northeast, and Southeast (67 stations). Such expansion would increase the size of the MAPS program by 300 stations (a 69% increase, or 733 total stations operated annually for ≥4 yr).

We used two methods to identify species for which survival could potentially be monitored effectively under such an expanded MAPS program. In the first method, which we call the expanded (non-targeted) program, we assume that, within each region, the relative geographic and habitat coverage and effectiveness of capturing birds in the expanded program would remain essentially the same as in the current program. Thus, new "monitorable species" were those for which expected sample size increases, calculated as proportional increases in annual releases of residents equal to proportional increases in the number of stations, reach a level that our power analyses suggest we can detect a ≤25% difference in survival between populations or ≤25% decline in survival with 80% power, $\alpha = 0.20$, and 20 years of data. We did not apply this method to the Northwest, as we believe that the current number and distribution of stations there is sufficient to effectively monitor an adequate number of species in the habitats sampled.

In the second method, which we call the expanded and targeted program, we assumed that new stations would be sited specifically to target species currently under-represented in the MAPS database, including species identified as monitorable in the expanded (but non-targeted) program. For the Northwest Region, target species were selected based on a formal analysis of the MAPS program funded by the U.S. Bureau of Land Management (Pyle et al. 2005). Specifically, we selected Northwest target species based on (1) their identification as focal or priority species in at least one priority habitat in at least one of 13 published Partners In Flight (PIF) bird conservation plans for the Northwest, or (2) their having negative population trends according to BBS or MAPS data in one or more states or Bird Conservation Regions (BCRs) in the Northwest. A few species with positive population trends were also selected for comparison. Priority habitats were identified by examining PIF habitat designations for Physiographic Areas in the Pacific Northwest and selecting those that can be effectively sampled by MAPS (i.e., forest and scrub areas). For the remaining regions, target species were selected as those thought to be monitorable, based on their habitats, ecology, and behavior, provided that a sufficient number of MAPS stations were operated.

RESULTS

POWER OF THE CURRENT MAPS PROGRAM

Our estimates of the numbers of resident birds released per year in the MAPS program suggest that we can detect differences in survival between populations or linear declines in survival with 80% power with 20 yr of data at the continental scale for 105 species (Table 3). About one third (36) are Partners In Flight (PIF) Species of Continental Importance ("Watch List" or "Additional Stewardship" species; Rich et al. 2004). Current MAPS sample sizes suggest we can detect (at $\alpha = 0.20$) effect sizes of 5% for nine species, 10% for an additional 38 species, 15% for an additional 33 species, 20% for an additional 13 species, and 25% for an additional 12 species. Increasing α from 0.10 to 0.20 resulted in relatively small increases in the numbers of species for which we can reject null hypotheses (Figs. 2-3).

MAPS program coverage is greatest in the Northwest Region, where we can currently detect differences in survival between populations or linear declines in survival with 80% power for 47 species (Figs. 2-3, Appendix 1). Five-percent effect sizes (for at least one of the hypothesis tests and $\alpha = 0.20$) could likely be detected for five of these species in the Northwest Region, while larger effect sizes could likely be detected for an additional 13 species at the 10% level, 21 species at the 15% level, six

TABLE 3. Effect sizes (%) currently detectable by MAPS with 20 yrs of data, and likely detectable under an expanded MAPS program, with 80% power at the program-wide (i.e., continental) scale. Two effect types were considered: (1) a two-population comparison of survival (2P), and (2) a population with linearly declining survival (LD). Effect sizes are given for two alpha-levels, 0.10 and 0.20.

	Current									Expanded			
						$\alpha = 0.10$		$\alpha = 0.20$		$\alpha = 0.10$		$\alpha = 0.20$	
Species	Sta[1]	Ind[2]	Res[3]	$\hat{\phi}$[4]	$\hat{p}$[5]	2P[6]	LD[7]	2P[6]	LD[7]	2P[6]	LD[7]	2P[6]	LD[7]
Red-naped Sapsucker (*Sphyrapicus nuchalis*)	32	489	55	0.413	0.602	25	15	20	15	20	15	15	15
Red-breasted Sapsucker (*Sphyrapicus ruber*)	49	701	77	0.458	0.369	20	15	20	15	15	15	15	10
Ladder-backed Woodpecker (*Picoides scalaris*)	16	98	10	0.552	0.292				25		25		20
Nuttall's Woodpecker (*Picoides nuttallii*)	16	195	22	0.551	0.381		20	25	15	25	15	20	15
Downy Woodpecker (*Picoides pubescens*)	227	1915	137	0.500	0.354	15	15	15	10	15	10	10	10
Hairy Woodpecker (*Picoides villosus*)	154	630	59	0.665	0.208	20	15	15	10	15	10	10	10
Western Wood-Pewee (*Contopus sordidulus*)	73	1456	135	0.486	0.362	15	15	15	10	15	10	10	10
Eastern Wood-Pewee (*Contopus virens*)	101	616	44	0.494	0.278		20	25	15	25	15	20	15
Acadian Flycatcher (*Empidonax virescens*)	66	2285	183	0.508	0.518	10	10	10	10	10	10	10	10
"Traill's" Flycatcher (*Empidonax alnorum/traillii*)	80	3105	198	0.485	0.491	10	10	10	10	10	10	10	10
Least Flycatcher (*Empidonax minimus*)	24	1044	73	0.379	0.435	25	15	20	15	20	15	15	15
Hammond's Flycatcher (*Empidonax hammondii*)	56	1155	114	0.452	0.403	20	15	15	15	15	10	10	10
Dusky Flycatcher (*Empidonax oberholseri*)	52	1986	147	0.485	0.425	15	10	10	10	10	10	10	10
"Western" Flycatcher (*E. difficilis/occidentalis*)	69	2573	161	0.504	0.282	15	15	15	10	10	10	10	10
Black Phoebe (*Sayornis nigricans*)	16	195	12	0.460	0.481				20		20		15
Ash-throated Flycatcher (*Myiarchus cinerascens*)	35	723	63	0.666	0.135	15	15	15	10	15	10	10	10
Great Crested Flycatcher (*Myiarchus crinitus*)	96	574	33	0.615	0.216				20		20	25	15
Brown-crested Flycatcher (*Myiarchus tyrannulus*)	4	225	30	0.492	0.276		20		20	25	15	20	15
White-eyed Vireo (*Vireo griseus*)	82	2719	267	0.537	0.509	10	10	10	10	10	10	10	10
Bell's Vireo (*Vireo bellii*)	17	562	57	0.581	0.404	20	15	15	10	15	10	10	10
Warbling Vireo (*Vireo gilvus*)	118	5017	379	0.483	0.428	10	10	10	10	5	10	5	10
Red-eyed Vireo (*Vireo olivaceus*)	159	4798	427	0.595	0.253	10	10	10	10	10	10	10	10
Steller's Jay (*Cyanocitta stelleri*)	60	303	20	0.731	0.184			25	25	25	20	20	15
Carolina Chickadee (*Poecile carolinensis*)	121	1312	95	0.499	0.229		20	25	15	25	15	20	15
Black-capped Chickadee (*Poecile atricapilla*)	144	3069	294	0.468	0.367	10	10	10	10	10	10	10	10
Mountain Chickadee (*Poecile gambeli*)	51	1145	93	0.452	0.385	20	15	15	15	15	15	15	10
Chestnut-backed Chickadee (*Poecile rufescens*)	51	1043	88	0.419	0.396		20	25	20	20	15	20	15
Boreal Chickadee (*Poecile hudsonica*)	10	132	19	0.492	0.365				25		20		20
Tufted Titmouse (*Baeolophus bicolor*)	137	1840	189	0.491	0.386	15	10	10	10	10	10	10	10
Bushtit (*Psaltriparus minimus*)	43	1117	152	0.295	0.146				25		25		25
White-breasted Nuthatch (*Sitta carolinensis*)	88	358	20	0.477	0.306				20		20		20

TABLE 3. Continued.

	Current									Expanded			
						α = 0.10		α = 0.20		α = 0.10		α = 0.20	
Species	Sta[1]	Ind[2]	Res[3]	$\hat{\phi}$[4]	$\hat{p}$[5]	2P[6]	LD[7]	2P[6]	LD[7]	2P[6]	LD[7]	2P[6]	LD[7]
Carolina Wren (*Thryothorus ludovicianus*)	124	2713	270	0.397	0.541	15	10	10	10	10	10	10	10
Bewick's Wren (*Thryomanes bewickii*)	72	1695	180	0.430	0.515	15	15	15	10	15	10	10	10
House Wren (*Troglodytes aedon*)	97	2863	267	0.341	0.420	25	20	20	15	20	15	15	15
Winter Wren (*Troglodytes troglodytes*)	46	967	78	0.376	0.506	25	15	20	15	20	15	15	15
Arctic Warbler (*Phylloscopus borealis*)	2	249	29	0.339	0.605		25		25		20	25	20
Veery (*Catharus fuscescens*)	54	2274	290	0.581	0.566	10	10	5	10	5	5	5	5
Gray-cheeked Thrush (*Catharus minimus*)	6	253	31	0.459	0.683	20	15	20	15	20	15	15	10
Swainson's Thrush (*Catharus ustulatus*)	109	10175	1113	0.581	0.624	5	5	5	5	5	5	5	5
Hermit Thrush (*Catharus guttatus*)	75	2170	229	0.474	0.607	10	10	10	10	10	10	5	10
Wood Thrush (*Hylocichla mustelina*)	128	4973	455	0.440	0.490	10	10	10	10	10	10	10	10
American Robin (*Turdus migratorius*)	269	7874	682	0.523	0.275	10	10	10	10	5	10	5	10
Varied Thrush (*Ixoreus naevius*)	40	493	34	0.471	0.394		20	25	15	25	15	20	15
Wrentit (*Chamaea fasciata*)	37	1325	145	0.534	0.627	10	10	10	10	10	10	10	10
Gray Catbird (*Dumetella carolinensis*)	121	9446	874	0.511	0.464	5	10	5	5	5	5	5	5
Brown Thrasher (*Toxostoma rufum*)	58	643	48	0.522	0.292	25	15	25	15	20	15	20	15
Long-billed Thrasher (*Toxostoma longirostre*)	3	133	14	0.628	0.396				20		20	25	15
Blue-winged Warbler (*Vermivora pinus*)	35	994	79	0.521	0.394	20	15	20	15	15	15	15	10
Orange-crowned Warbler (*Vermivora celata*)	72	3875	268	0.441	0.435	15	10	10	10	10	10	10	10
Nashville Warbler (*Vermivora ruficapilla*)	34	1111	60	0.338	0.331				25		25		25
Virginia's Warbler (*Vermivora virginiae*)	12	463	30	0.473	0.339		20		20	25	15	25	15
Yellow Warbler (*Dendroica petechia*)	123	9049	816	0.534	0.474	5	10	5	10	5	5	5	5
Chestnut-sided Warbler (*Dendroica pensylvanica*)	22	839	88	0.431	0.545	20	15	20	15	15	15	15	15
Magnolia Warbler (*Dendroica magnolia*)	15	514	39	0.321	0.769		20	25	20	25	20	20	20
Yellow-rumped Warbler (*Dendroica coronata*)	97	4216	328	0.451	0.276	10	10	10	10	10	10	10	10
Black-thr. Green Warbler (*Dendroica virens*)	19	372	39	0.396	0.557		20	25	20	25	20	20	15
Townsend's Warbler (*Dendroica townsendi*)	27	978	101	0.428	0.224		25		25		20		20
Blackpoll Warbler (*Dendroica striata*)	7	177	14	0.313	0.735				25		25		25
Black-and-white Warbler (*Mniotilta varia*)	75	1105	91	0.518	0.298	20	15	15	15	15	15	15	10
American Redstart (*Setophaga ruticilla*)	60	3204	264	0.509	0.338	10	10	10	10	10	10	10	10
Prothonotary Warbler (*Protonotaria citrea*)	20	479	49	0.509	0.206				25		20		20
Worm-eating Warbler (*Helmitheros vermivorus*)	30	781	60	0.529	0.402	25	15	20	15	20	15	15	15
Ovenbird (*Seiurus aurocapillus*)	112	3873	324	0.550	0.430	5	10	5	5	5	5	5	5
Northern Waterthrush (*Seiurus noveboracensis*)	20	491	37	0.498	0.550	25	15	20	15	20	15	15	15

TABLE 3. Continued.

Species	Current									Expanded			
						α = 0.10		α = 0.20		α = 0.10		α = 0.20	
	Sta[1]	Ind[2]	Res[3]	$\hat{\phi}$[4]	$\hat{p}$[5]	2P[6]	LD[7]	2P[6]	LD[7]	2P[6]	LD[7]	2P[6]	LD[7]
Louisiana Waterthrush (*Seiurus motacilla*)	35	561	50	0.514	0.583	20	15	15	10	15	10	15	10
Kentucky Warbler (*Oporornis formosus*)	53	1834	197	0.539	0.585	10	10	10	10	10	10	5	10
Mourning Warbler (*Oporornis philadelphia*)	7	230	30	0.444	0.389				25		25		20
MacGillivray's Warbler (*Oporornis tolmiei*)	92	5887	596	0.477	0.612	5	10	5	10	5	5	5	5
Common Yellowthroat (*Geothlypis trichas*)	175	8523	777	0.481	0.500	5	10	5	10	5	5	5	5
Hooded Warbler (*Wilsonia citrina*)	47	1221	109	0.489	0.536	15	10	15	10	10	10	10	10
Wilson's Warbler (*Wilsonia pusilla*)	82	9116	593	0.416	0.530	10	10	10	10	10	10	5	10
Canada Warbler (*Wilsonia canadensis*)	10	314	23	0.443	0.544		25		20		20	25	20
Yellow-breasted Chat (*Icteria virens*)	74	3044	328	0.468	0.474	10	10	10	10	10	10	5	10
Summer Tanager (*Piranga rubra*)	57	566	49	0.486	0.417	25	15	25	15	20	15	20	15
Western Tanager (*Piranga ludoviciana*)	86	1769	120	0.542	0.141	25	20	25	15	20	15	20	15
Olive Sparrow (*Arremonops rufivirgatus*)	3	208	27	0.510	0.738	20	15	20	15	15	15	15	10
Green-tailed Towhee (*Pipilo chlorurus*)	13	297	28	0.541	0.355		20		20		15	25	15
Spotted Towhee (*Pipilo maculatus*)	78	2125	223	0.487	0.465	10	10	10	10	10	10	10	10
Eastern Towhee (*Pipilo erythrophthalmus*)	97	907	98	0.484	0.331	20	15	15	15	15	15	15	10
California Towhee (*Pipilo crissalis*)	18	398	49	0.539	0.353	25	15	25	15	20	15	20	15
Rufous-crowned Sparrow (*Aimophila ruficeps*)	14	175	17	0.545	0.334				25		20		20
American Tree Sparrow (*Spizella arborea*)	7	199	17	0.483	0.500		20		20		15	25	15
Chipping Sparrow (*Spizella passerina*)	77	1326	129	0.410	0.231		25		20		20	25	20
Field Sparrow (*Spizella pusilla*)	67	2032	219	0.447	0.350	20	15	15	15	15	15	15	10
Lark Sparrow (*Chondestes grammacus*)	17	422	17	0.522	0.275				25		20		20
Savannah Sparrow (*Passerculus sandwichensis*)	12	504	43	0.536	0.360		20	25	15	25	15	20	15
Fox Sparrow (*Passerella iliaca*)	41	991	92	0.534	0.502	15	15	15	10	15	10	10	10
Song Sparrow (*Melospiza melodia*)	185	10465	1160	0.465	0.560	5	10	5	5	5	5	5	5
Lincoln's Sparrow (*Melospiza lincolnii*)	52	2528	329	0.424	0.634	10	10	10	10	10	10	10	10
Swamp Sparrow (*Melospiza georgiana*)	14	332	29	0.402	0.748	25	20	25	15	20	15	20	15
White-throated Sparrow (*Zonotrichia albicollis*)	19	992	97	0.351	0.532	20	15	20	15	15	15	15	10
White-crowned Sparrow (*Zonotrichia leucophrys*)	30	1260	140	0.459	0.479	15	10	10	10	10	10	10	10
Golden-crowned Sparrow (*Zonotrichia atricapilla*)	5	279	34	0.533	0.490	25	15	20	15	20	15	15	15
Dark-eyed Junco (*Junco hyemalis*)	121	6505	722	0.442	0.503	10	10	10	10	5	10	5	10
Northern Cardinal (*Cardinalis cardinalis*)	177	6027	631	0.568	0.370	5	10	5	5	5	5	5	5
Black-headed Grosbeak (*Pheucticus melanocephalus*)	104	3796	295	0.550	0.303	10	10	10	10	5	10	5	10
Lazuli Bunting (*Passerina amoena*)	47	1719	99	0.496	0.297	20	15	15	15	15	10	15	10

TABLE 3. Continued.

	Current									Expanded			
						α = 0.10		α = 0.20		α = 0.10		α = 0.20	
Species	Sta[1]	Ind[2]	Res[3]	$\hat{\phi}$[4]	$\hat{p}$[5]	2P[6]	LD[7]	2P[6]	LD[7]	2P[6]	LD[7]	2P[6]	LD[7]
Indigo Bunting (*Passerina cyanea*)	112	3698	352	0.490	0.371	10	10	10	10	10	10	10	10
Painted Bunting (*Passerina ciris*)	32	1592	115	0.558	0.439	10	10	10	10	10	10	10	10
Red-winged Blackbird (*Agelaius phoeniceus*)	69	1934	96	0.612	0.200	20	15	20	15	15	15	15	10
Brown-headed Cowbird (*Molothrus ater*)	210	2023	180	0.473	0.460	10	10	10	10	10	10	10	10
Baltimore Oriole (*Icterus galbula*)	43	687	46	0.534	0.287	25	15	25	15	20	15	20	15
Bullock's Oriole (*Icterus bullockii*)	39	1141	68	0.469	0.365	25	15	20	15	20	15	15	15
Purple Finch (*Carpodacus purpureus*)	51	3459	259	0.460	0.340	10	10	10	10	10	10	10	10
American Goldfinch (*Carduelis tristis*)	135	6624	514	0.430	0.266	20	15	15	15	15	15	15	10

[1] Number of stations that were operated for at least four consecutive years during the 10-yr period 1992-2001 at which (a) at least one adult individual of the species was captured and (b) the species was a regular or usual breeder. Stations within 1 km of each other were merged into a single "super-station" to prevent individuals whose home range encompassed parts of both stations from being treated as two individuals.

[2] Total number of individual adult birds captured during the 10-yr period 1992-2001 at stations where the species was a regular or usual breeder; thus the total number of capture histories upon which the estimate of survival probability was based.

[3] Estimated number of resident birds released per year as part of a stable MAPS program at the current level of effort. See text for detail.

[4] Estimated time-constant annual apparent survival rate from MAPS data pooled across all stations from 1992-2001.

[5] Estimated time-constant recapture probability from MAPS data pooled across all stations from 1992-2001.

[6] Effect size (% difference) that can be detected when comparing the adult apparent survival rates between two populations, based on results of simulated data and current MAPS sample sizes and parameter estimates.

[7] Effect size (% change) that can be detected for a population experiencing a linear decline in adult apparent survival, based on results of simulated data and current MAPS sample sizes and parameter estimates.

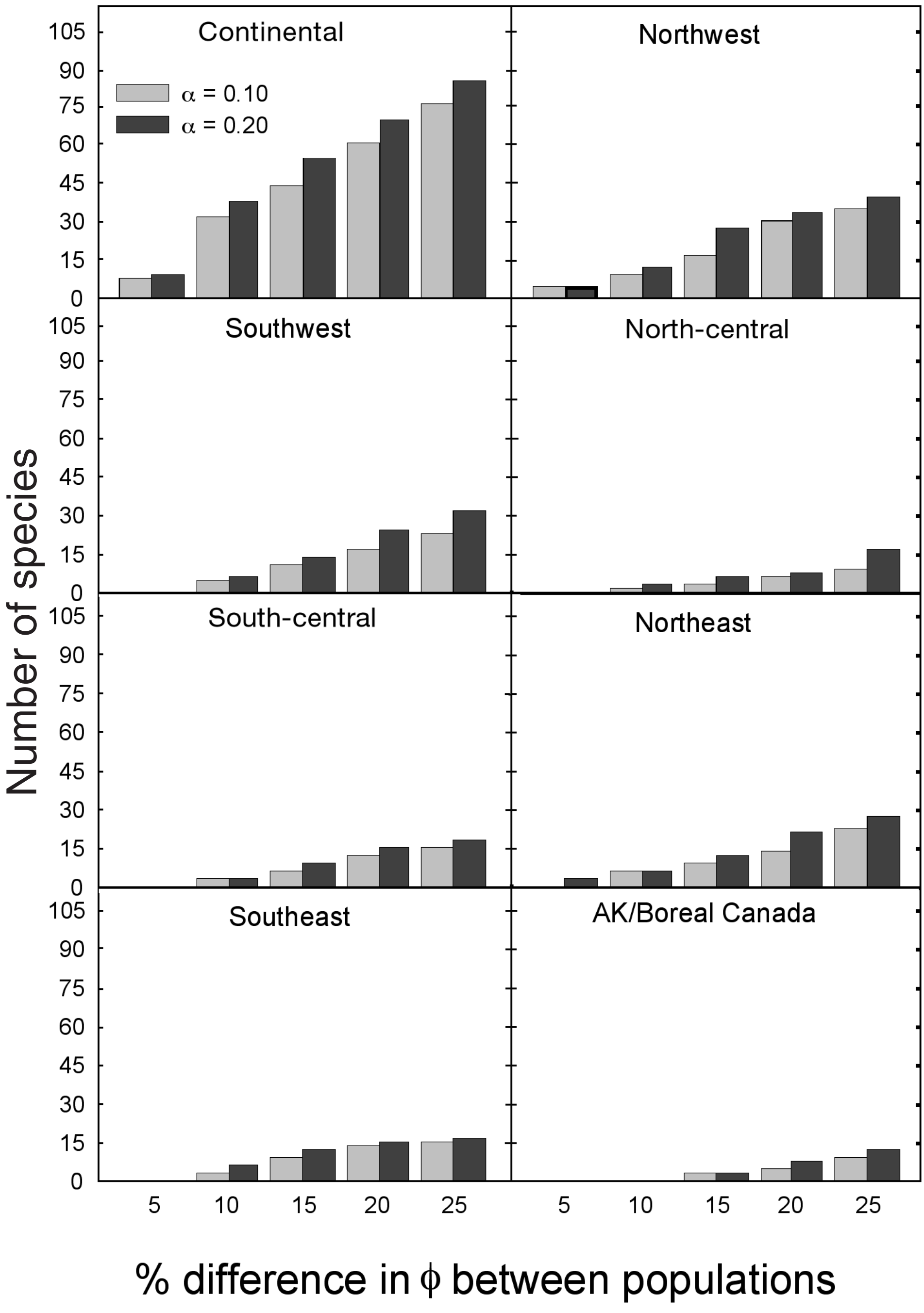

FIGURE 2. Numbers of species for which current MAPS sample sizes suggest that we could likely detect differences in adult apparent survival (ϕ) between populations with 20 yr of data.

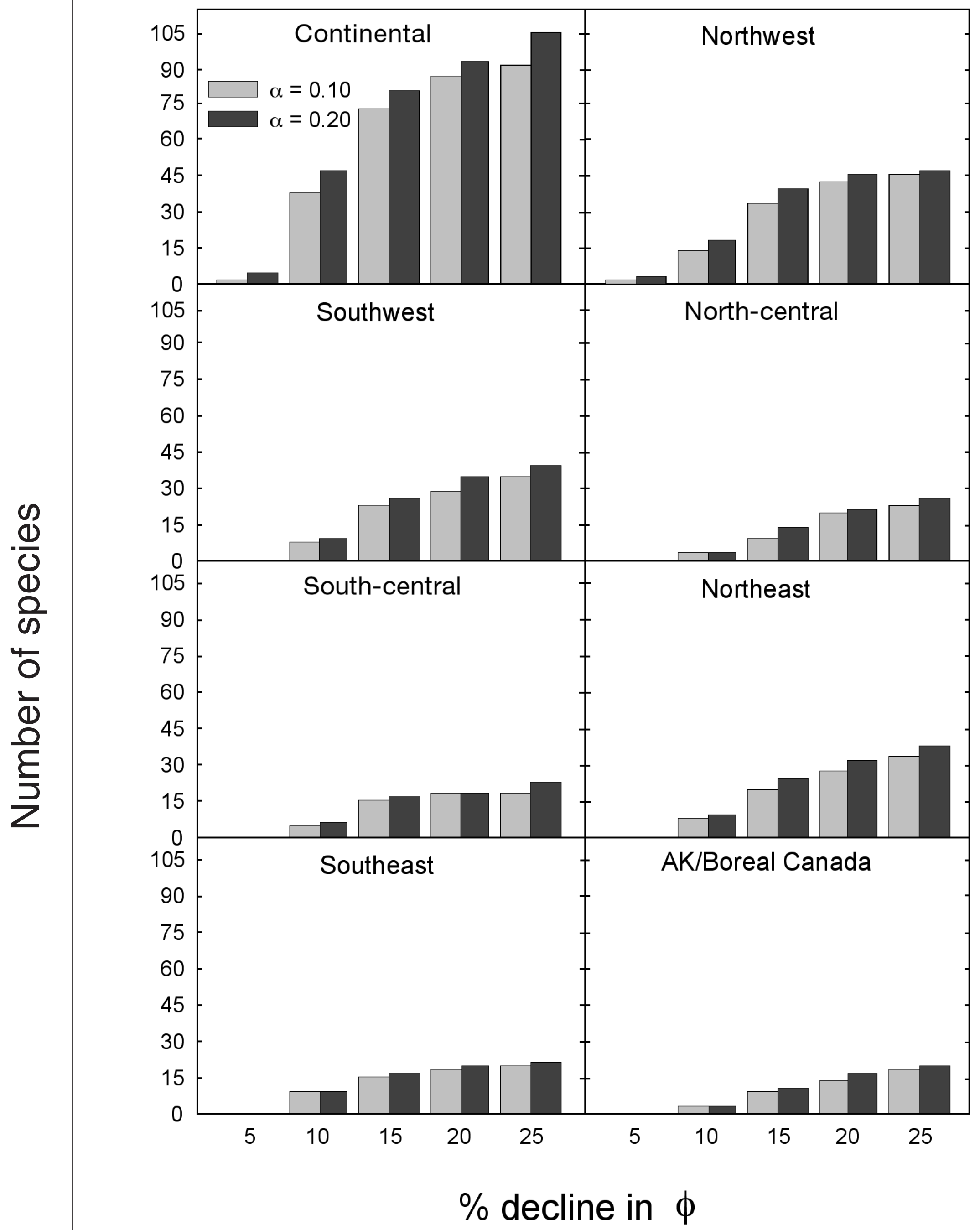

FIGURE 3. Numbers of species for which current MAPS sample sizes suggest that we could likely detect linear declines in adult apparent survival (ϕ) with 20 yr of data.

species at the 20% level, and two species at the 25% level. Scrub/successional/disturbed, Pacific Northwest conifer forest, western conifer forest, and western riparian forest habitats were all well represented as "adequately" monitored with 25, 27, 24, and 22 species, respectively (Appendix 1). Western oak or juniper woodland and chaparral/sagebrush shrub-steppe habitats were not well monitored with only five "adequately" monitored species each.

Lists of currently monitorable species and the effect sizes that can be detected with 80% power in the remaining six regions are also shown graphically in Figures 2 and 3 and presented in Appendices 2-7. Numbers of currently monitorable species are similar for the Southwest and Northeast regions, with tallies of 42 and 38 species, respectively (Appendices 2 and 5). Current sample sizes are sufficient to detect a 5% difference in survival between populations with $\alpha = 0.20$ and 20 yr of data for two species in the Northeast (Appendix 5), but are insufficient to detect 5% effect sizes for any other species or scenario in either of these two regions. At the 10% effect size, nine species are currently monitorable in the Southwest Region (Appendix 2) and an additional six species are monitorable in the Northeast Region (Appendix 5). The remaining species are sampled in sufficient numbers to detect only larger effect sizes. Scrub/successional/disturbed, western conifer forest, and western riparian forest habitats were well represented in the Southwest Region by 21, 18, and 20 "adequately" monitored species, respectively (Appendix 2). Western oak or juniper woodland habitat had 14 "adequately" monitored species but chaparral/sagebrush shrub-steppe habitat had only five "adequately" monitored species. In the Northeast Region, scrub/successional/disturbed, northern hardwood, and southern hardwood habitats were well represented by 17, 18, and 19 "adequately" monitored species, respectively (Appendix 5), while northern conifer habitat had only 11 "adequately" monitored species and southern conifer habitat, which has a very limited distribution in the Northeast Region, had only four "adequately" monitored species.

Currently monitorable species in the four remaining MAPS regions ranged from 19 in the Alaska/Boreal Canada Region to 25 in the North-central Region (Figs. 2-3; Appendices 3-4 and 6-7). No species was sampled sufficiently to detect 5% effect sizes with 80% power in any of these remaining regions. However, 10% effect sizes can likely be detected in the North-central, South-central, Southeast, and Alaska/Boreal Canada regions for 3, 6, 9, and 3 species respectively, while 15% effect sizes can likely be detected for 10, 10, 7, and 7 additional species, respectively. In general, scrub/successional/disturbed, northern hardwood, and southern hardwood habitats were well represented according to the extent of their distributions by "adequately" monitored species in each of the North-central, South-central, and Southeast regions; both northern conifer and southern conifer habitats were less well represented in those regions. Scrub/successional/disturbed, boreal conifer, and boreal hardwood habitats were represented by 11, 9, and 6 "adequately" monitored species, respectively, in the Alaska/Boreal Canada Region, likely substantially below the numbers of potentially monitorable species.

We were able to estimate survival rates on at least two of the six Pacific Northwest national forests for 21 species. At $\alpha = 0.20$, we found we could detect 10% differences in survival for one species (Swainson's Thrush), 15% differences in survival for five additional species (American Robin, MacGillivray's Warbler, Wilson's Warbler, Lincoln's Sparrow, and Dark-eyed Junco), 20% differences for three additional species (Dusky Flycatcher, Warbling Vireo, and Song Sparrow), and 25% differences for six additional species (Hammond's Flycatcher, "Western" Flycatcher, Winter Wren, Yellow Warbler, Yellow-rumped Warbler, and Common Yellowthroat), for a total of 15 of the 21 species (Fig. 4). Interestingly, the mean maximum difference in survival between forests for the 13 species with CV($\hat{\phi}$) <20% at both forests was 14.8%; the mean maximum difference for all 21 species (regardless of CV($\hat{\phi}$)) was 25.5%. It is not surprising, therefore, that we had 80% power to detect the magnitude of the difference in survival that actually existed between the two national forests for eight of the 15 species for which we could detect at least a 25% difference in survival

POWER OF AN EXPANDED MAPS PROGRAM

Under the expanded (i.e., non-targeted) MAPS program, the number of species whose survival

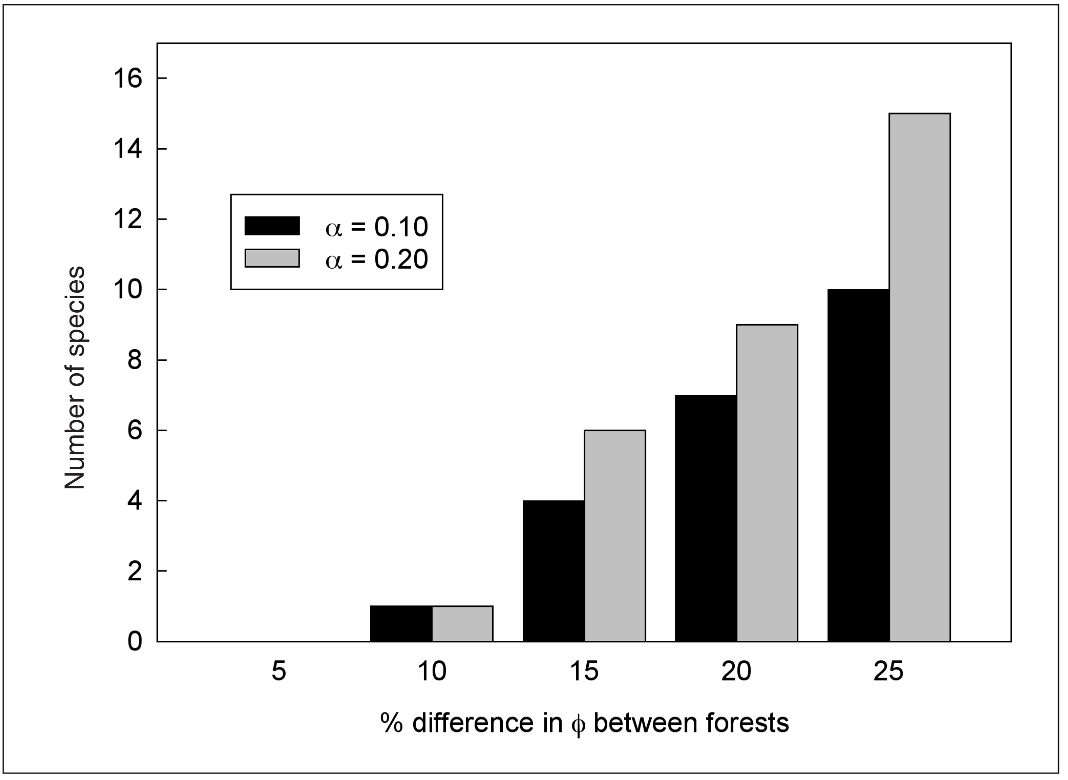

FIGURE 4. Numbers of species for which we would be able to detect differences in survival between clusters of six stations on national forest lands in the Pacific Northwest with 80% power over 20 yr. Calculations assume that capture rates, proportions of residents captured, and survival and recapture probabilities all remained as documented on each national forest during 1992-2001.

would likely be monitorable at the continental scale would increase by just 13%, despite an overall increase in the number of stations of 65% (to 713 stations) (Table 4; new species under expanded (E) or expanded and targeted (T) scenarios are listed in Table 5). The gain in monitorable species under the expanded scenario was also small at the MAPS-regional scale. The number of new monitorable species increased by an average of only 22% over the six expanded regions (ranging from 9% in the South-central Region to 37% in the Alaska/Boreal Canada Region), despite the number of stations increasing by an average of 104% over these regions (ranging from 34% in the South-central Region to 205% in the Alaska/Boreal Canada Region). The numbers of species monitorable at smaller effect sizes, however, increased markedly under the expanded program for both the continental and regional scales (Figs. 5-6; changes in monitorable effect sizes for individual species are listed in Table 3 for continental and Appendices 1-7 for MAPS regions). For example, the number of species for which 5% linear declines would likely be detectable at the continental scale under the expanded program increased by 160% (from 5 to 13 species). As perhaps expected, the 14 monitorable species added at the continental scale by the expanded but not targeted program scenario (Table 5) were typical of habitats already well represented by "adequately" monitored species. Only one boreal forest species (Olive-sided Flycatcher) and two western oak or juniper woodland species (Oak and Juniper titmice) were added.

Under the expanded and targeted program scenario, survival rates of many additional species could likely be monitored effectively by MAPS (Table 4). At the continental scale, the

TABLE 4. Numbers of monitorable species in the current MAPS program and expected numbers under expanded or expanded/targeted MAPS programs.

	Region[1]							
	NW	SW	NC	SC	NE	SE	AC	Continental
No. of stations[2]								
Current	128	66	32	50	65	70	22	433
Expanded	128	128	67	67	128	128	67	713
Expanded/targeted	148	128	67	67	128	128	67	733
No. of species[3]								
Current	47	42	25	22	38	21	19	105
Expanded	47	50	34	24	47	23	26	119
Expanded/targeted	63	65	49	49	62	40	43	146

[1] See Fig. 1 for region definitions and boundaries.
[2] Number of stations operated annually that are operated for at least four consecutive years.
[3] Number of species for which survival can be monitored effectively (i.e., for which 25% differences in survival between two populations or a "25%" linear decline in survival in a single population can be detected with 80% power at alpha = 0.2 with 20 years of data).

expanded and targeted scenario would result in a 39% increase in monitorable species (from 105 to 146 species), and a 23% increase over the expanded program (from 119 to 146 species). The 27 new monitorable species at the continental scale from the expanded and targeted scenario (Tables 4 and 5) include (asterisks indicate species for which MAPS can currently obtain continental-scale survival-rate estimates): (1) five species typical of western oak or juniper woodland habitat (Gray Flycatcher, *Plumbeous Vireo, *Hutton's Vireo, *Bridled Titmouse, *Black-throated Gray Warbler); (2) seven species typical of sagebrush shrubsteppe or desert scrub and canyons of the West and Southwest (*Verdin, Sage Thrasher, Canyon Towhee, Brewer's Sparrow, *Vesper Sparrow, *Black-throated Sparrow, *Sage Sparrow); (3) 12 species that breed in the boreal forest and, for some, also in northern conifer habitat (*Yellow-bellied Sapsucker, Yellow-bellied Flycatcher, *Blue-headed Vireo, Philadelphia Vireo, *Gray Jay, *Ruby-crowned Kinglet, *Bicknell's Thrush, Tennessee Warbler, *Black-throated Blue Warbler, Palm Warbler, Bay-breasted Warbler, and *Clay-colored Sparrow); and (4) three other species from central and eastern North America (*Blue Jay, *Swainson's Warbler, and *Dickcissel).

At the regional scale, targeted expansion of just 20 stations in the Northwest (a 16% increase in stations) could result in a 34% increase the number of effectively monitored species there (Tables 4 and 5). Targeted expansion in the remaining MAPS regions could increase the number of monitorable species by an average of 96% (ranging from 55% in the Southwest to 132% in the South-central Region; Tables 4 and 5).

DISCUSSION

Although our power analyses demonstrate the difficulty of detecting small (5-10%) differences in survival between populations or linear declines in survival in a single population given sample sizes currently being obtained by the MAPS program, the typical effect sizes seen in MAPS data are often much larger. Indeed, our results suggest that we can detect differences and declines in survival of the magnitudes of differences typically seen between MAPS regions or between clusters of MAPS stations with 80% power for 84 and 105 species, respectively, at the continental scale, and for 40 and 47 species, respectively, in the Northwest Region (the region with the largest number of MAPS stations). The numbers of adequately monitored species are smaller in the remaining six regions; clearly, expansion of MAPS in those regions will increase its usefulness as a component of continental scale CBM.

Whether a particular species is captured in sufficient numbers to detect differences in survival between populations or changes in survival within a given population over time

TABLE 5. Additional species that would likely be monitorable with 20 yr of data under an expanded (E) or targeted and expanded (T) MAPS program at continental and regional scales. (Note, √ indicates already monitorable under the current program.)

	Region[1]							
	NW	SW	NC	SC	NE	SE	AC	Cont[2]
Yellow-bellied Sapsucker (*Sphyrapicus varius*)					T		T	T
Red-breasted Sapsucker (*Sphyrapicus ruber*)	√	E						√
Ladder-backed Woodpecker (*Picoides scalaris*)				T				√
Downy Woodpecker (*Picoides pubescens*)	T	√	E	T	√	√		√
Hairy Woodpecker (*Picoides villosus*)	√	E	E		T	T		√
Olive-sided Flycatcher (*Contopus cooperi*)		√						E
Western Wood-Pewee (*Contopus sordidulus*)	√	√	E				E	√
Eastern Wood-Pewee (*Contopus virens*)			T	T	E	T		√
Yellow-bellied Flycatcher (*Empidonax flaviventris*)							T	T
Acadian Flycatcher (*Empidonax virescens*)				√	T	√		√
Gray Flycatcher (*Empidonax wrightii*)	T	T						T
Black Phoebe (*Sayornis nigricans*)		E						√
Eastern Phoebe (*Sayornis phoebe*)					√			E
Great Crested Flycatcher (*Myiarchus crinitus*)			E	T	T	T		√
Brown-crested Flycatcher (*Myiarchus tyrannulus*)				T				√
Bell's Vireo (*Vireo belli*)		T						√
Plumbeous Vireo (*Vireo plumbeus*)		T						T
Cassin's Vireo (*Vireo cassinii*)	T							E
Blue-headed Vireo (*Vireo solitarius*)					T		T	T
Hutton's Vireo (*Vireo huttoni*)	T							T
Warbling Vireo (*Vireo gilvus*)	√	√	T					√
Philadelphia Vireo (*Vireo philadelphicus*)							T	T
Red-eyed Vireo (*Vireo olivaceus*)	T		√	√	√	√		√
Gray Jay (*Perisoreus canadensis*)							E	T
Blue Jay (*Cyanocitta cristata*)			T		√	T		T
Tree Swallow (*Tachycineta bicolor*)								E
Barn Swallow (*Hirundo rustica*)								E
Carolina Chickadee (*Poecile carolinensis*)				T	√	√		√
Chestnut-backed Chickadee (*Poecile rufescens*)	T	√						√
Bridled Titmouse (*Baeolophus wollweberi*)		E						T
Oak Titmouse (*Baeolophus inornatus*)		√						E
Juniper Titmouse (*Baeolophus ridgwayi*)		√						E
Black-crested Titmouse (*Baeolophus atricristatus*)				T				E
Verdin (*Auriparus flaviceps*)		T						T
Bushtit (*Psaltriparus minimus*)	T	√						√
White-breasted Nuthatch (*Sitta carolinensis*)		E	T		T			√
Carolina Wren (*Thryothorus ludovicianus*)			E	√	E	√		√
House Wren (*Troglodytes aedon*)	√	√	√	E	E	T		√
Ruby-crowned Kinglet (*Regulus calendula*)	√						T	T
Bicknell's Thrush (*Catharus bicknelli*)					T			T
Wood Thrush (*Hylocichla mustelina*)			√	T	√	√		√
American Robin (*Turdus migratorius*)	√	√	√	T	√	T	E	√
Sage Thrasher (*Oreoscoptus montanus*)	T	T						T
Brown Thrasher (*Toxostoma rufum*)			T	√	T	T		√
Blue-winged Warbler (*Vermivora pinus*)			E	√	√	√		√
Tennessee Warbler (*Vermivora peregrina*)							T	T
Nashville Warbler (*Vermivora ruficapilla*)	T		T		T		T	√
Virginia's Warbler (*Vermivora virginiae*)	T		√					√
Lucy's Warbler (*Vermivora luciae*)		E						E
Northern Parula (*Parula americana*)				T	E	T		E

TABLE 5. Continued.

	Region[1]							
	NW	SW	NC	SC	NE	SE	AC	Cont[2]
Yellow Warbler (*Dendroica petechia*)	√	√	√	√	√	T	√	√
Magnolia Warbler (*Dendroica magnolia*)			T		√		T	√
Black-throated Blue Warbler (*Dendroica caerulescens*)					E			T
Yellow-rumped Warbler (*Dendroica coronata*)	√	T	T		√		√	√
Black-throated Gray Warbler (*Dendroica nigrescens*)	T	T						T
Black-throated Green Warbler (*Dendroica virens*)			T		√		T	√
Townsend's Warbler (*Dendroica townsendi*)	√						E	√
Prairie Warbler (*Dendroica discolor*)				T		T		E
Palm Warbler (*Dendroica palmarum*)							T	T
Bay-breasted Warbler (*Dendroica castanea*)							T	T
Blackpoll Warbler (*Dendroica striata*)					T		E	√
Black-and-white Warbler (*Mniotilta varia*)			E	T	√	T	T	√
American Redstart (*Setophaga ruticilla*)	√		√	T	√	T	√	√
Prothonotary Warbler (*Protonotaria citrea*)				T		E		√
Worm-eating Warbler (*Helmitheros vermivorus*)				T	√	√		√
Swainson's Warbler (*Limnothlypis swainsonii*)				T		T		T
Ovenbird (*Seiurus aurocapillus*)			E	T	√	√	T	√
Northern Waterthrush (*Seiurus noveboracensis*)	T		T		E		√	√
Louisiana Waterthrush (*Seiurus motacilla*)				T	√	√		√
Kentucky Warbler (*Oporornis formosus*)			√	√	E	√		√
Mourning Warbler (*Oporornis philadelphia*)			√		T		T	√
MacGillivray's Warbler (*Oporornis tolmiei*)	√	T						√
Common Yellowthroat (*Geothlypis trichas*)	√	√	√	√	√	√	T	√
Hooded Warbler (*Wilsonia citrina*)				T	√	√		√
Canada Warbler (*Wilsonia canadensis*)			T		T		√	√
Summer Tanager (*Piranga rubra*)				√		E		√
Western Tanager (*Piranga ludoviciana*)	√	E						√
Eastern Towhee (*Pipilo erythrophthalmus*)			T	T	√	√		√
Canyon Towhee (*Pipilo fuscus*)		T						T
Rufous-crowned Sparrow (*Aimophila ruficeps*)		T		T				√
Chipping Sparrow (*Spizella passerina*)	T	T	T		E		T	√
Clay-colored Sparrow (*Spizella pallida*)			T					T
Brewer's Sparrow (*Spizella breweri*)	T	T						T
Field Sparrow (*Spizella pusilla*)			√	√		T		√
Vesper Sparrow (*Pooecetes gramineus*)	T	T						T
Lark Sparrow (*Chondestes grammacus*)		E		T				√
Black-throated Sparrow (*Amphispiza bilineata*)		T						T
Sage Sparrow (*Amphispiza belli*)	T	T						T
Savannah Sparrow (*Passerculus sandwichensis*)	√						E	√
Grasshopper Sparrow (*Ammodramus savannarum*)				E				E
Lincoln's Sparrow (*Melospiza lincolnii*)	√		E				E	√
White-throated Sparrow (*Zonotrichia albicollis*)			√				T	√
Dark-eyed Junco (*Junco hyemalis*)	√				E		√	√
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)			T		T			E
Blue Grosbeak (*Passerina caerulea*)		√		T		T		E
Dickcissel (*Spiza americana*)				T				T
Brown-headed Cowbird (*Molothrus ater*)	√	√	√	√	T	T		√
Purple Finch (*Carpodacus purpureus*)	√	√			T			√
American Goldfinch (*Carduelis tristis*)	√		√	T	√	T		√

[1] See Fig. 1 for region definitions.
[2] Continental scale.

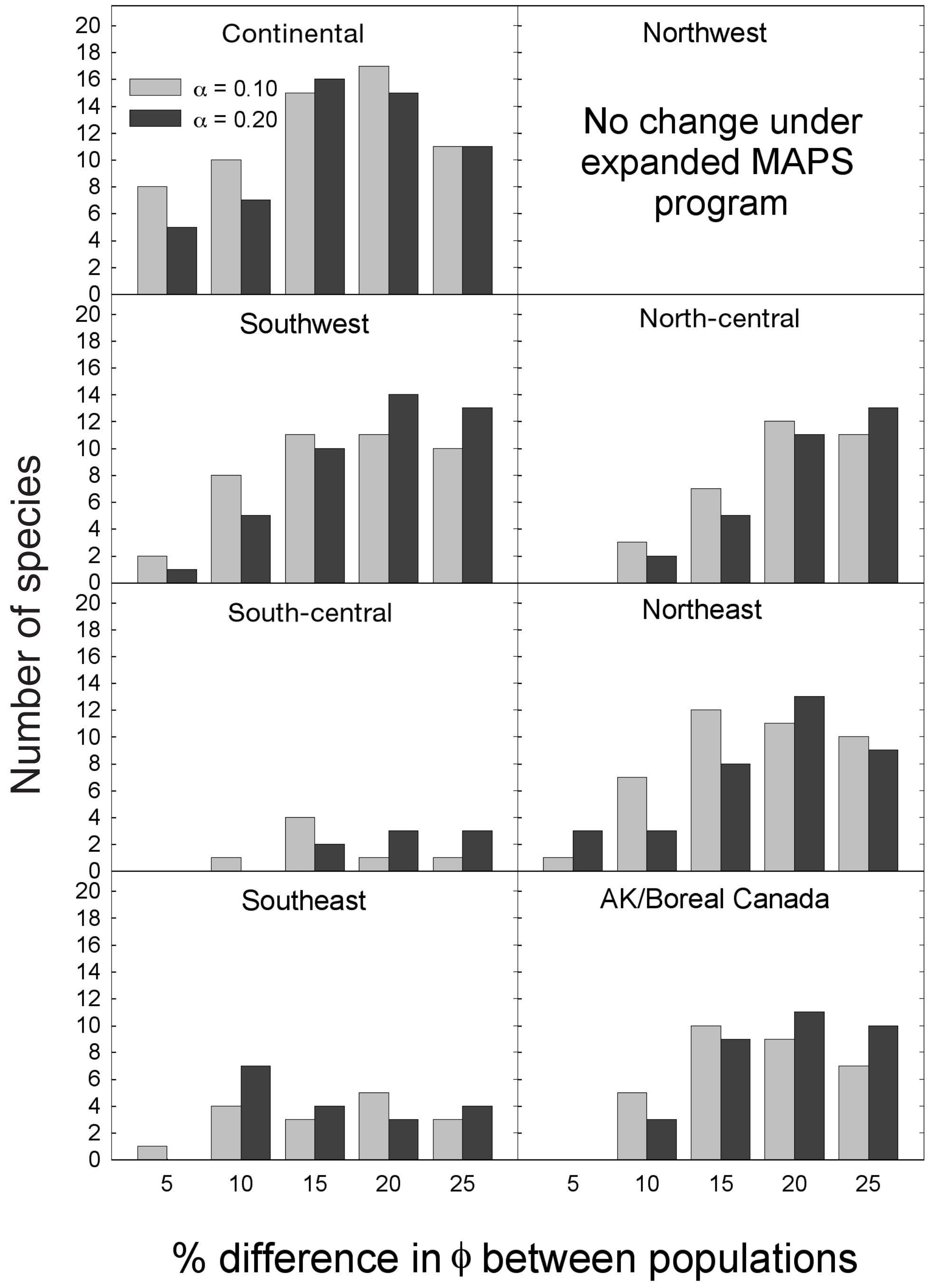

FIGURE 5. Numbers of new species for which we would likely be able to detect differences in survival (ϕ) between populations with 20 yr of data under an expanded (but not targeted) MAPS program.

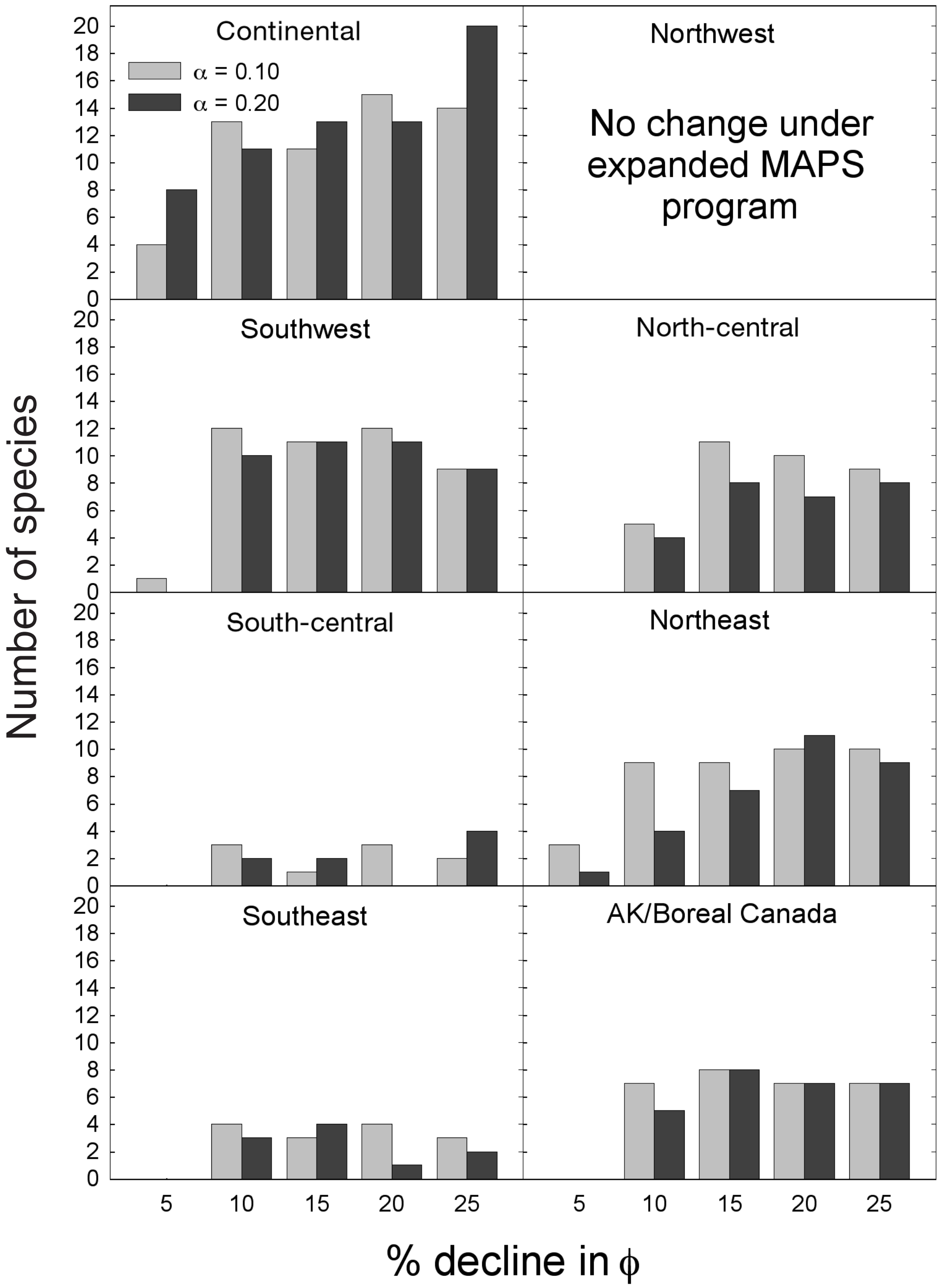

FIGURE 6. Numbers of new species for which we would likely be able to detect linear declines in survival (ϕ) with 20 yr of data under an expanded (but not targeted) MAPS program.

depends to some degree on annual variation in survival rates. As such, our calculations of the numbers of species for which survival may be effectively monitored (i.e., "monitorable species", see Methods: Evaluation of an Expanded Maps Program) at particular spatial scales may be slightly overestimated. Nevertheless, we rarely find strong evidence of time-dependent survival in MAPS data. In fact, only 46 (11%) of 411 species/region combinations for which we were able to obtain survival rate estimates with the 10-yr 1992-2001 data set showed strong evidence of time dependence (i.e., models with temporally varying survival were within 2 AIC units of time-constant models in only 11% of these cases; DeSante and Kaschube 2006). Thus, our estimates of numbers of currently monitorable species are likely reasonable.

Our assessment of program expansion options indicates that a focused approach targeting under-represented species and habitats will be required to maximize the number of species and habitats adequately monitored by MAPS. We suggest that target species be selected based not only on their habitats and ecology (and thus their inherent monitorability), but also on their status as species of conservation concern or whether they represent habitats of special management concern. This is the approach that we used to identify new target species in both the Northwest (Pyle et al. 2005) and Northeast (DeSante et al. 2008); similar analyses will need to be conducted for the remaining regions to best direct respective sampling strategies. The addition and redistribution of stations in the Northwest, as well as the undertaking of analyses to guide MAPS in the remaining six regions, would clearly be facilitated by the integration of MAPS into a broader CBM effort.

In order to address finer-scale monitoring needs, we suggest that MAPS will be most useful if sampling is targeted to capture a limited number of focal species and habitats (or management regimes), or possibly by sampling along a simple habitat gradient. For example, in our cluster-scale analysis of Pacific Northwest national forests, we were able to compare survival rate estimates for 21 species between various 6-station clusters. About half of these species met our criteria for being "adequately monitorable", and many of these were monitorable at an effect size that was actually seen (based on our estimates) between clusters of stations. Yet, an individual species being compared between clusters was often either absent or rare at many of the stations in the two clusters because stations were set up to sample a broad range of species and habitats. For example, the average number of stations at which a species was present (as a breeding resident) on the two clusters where it was most abundant was just 9.1 (out of 12 possible stations). A more focused sampling strategy would be to select a species (or set of species) of conservation concern and two habitats (e.g., three stations in each of two habitat types in each cluster) or a single habitat gradient. Such a hypothesis-driven design would require only two teams of banders (each operating six stations) and should be capable of providing inference on habitat factors influencing survival and reproduction.

The targeted hypothesis-driven sampling strategy described above lends itself well to management, as it provides testable hypotheses regarding habitat types or characteristics that promote better survival (or productivity) in populations of species of conservation concern. A similar sampling strategy can be employed to monitor demographic responses to management actions (i.e., effectiveness monitoring). Each of these targeted hypothesis-driven monitoring efforts directly supports management, has been referred to as "management-based" monitoring by the Coordinated Bird Monitoring Working Group (2004) or "targeted" monitoring by the NABCI Monitoring Subcommittee (2006), and was distinguished in those reports from "surveillance" (Coordinated Bird Monitoring Working Group 2004) or "broad-scale" (NABCI Monitoring Subcommittee 2006) monitoring, for which the goals were, among others, to provide essential information for prioritizing species for conservation actions and to identify emerging conservation issues. We feel that the distinction between "management-based" monitoring and "surveillance" monitoring is somewhat artificial, and suggest that they reflect, to some extent, the spatio-temporal continuum of questions that monitoring data can address. What is usually considered to be "management-based" monitoring typically requires a spatially intensive sampling effort that can assess changes over relatively short time frames, while what is usually considered to be "surveillance" monitoring typically requires a spatially extensive sampling effort over a long time scale.

We argue that the MAPS is well-suited to fulfilling both "management-based" and "surveillance" monitoring goals. Indeed, the optimal sampling design of the overall MAPS program can be envisioned as collections of targeted, hypothesis-driven sampling strategies at local spatial scales that are integrated into larger regional sampling schemes. The latter, in turn, can provide much of the necessary effort required for "surveillance" monitoring at regional and continental scales. In such an overall strategy, each local hypothesis-driven sampling scheme of about 12 stations would aim for the 20-yr time horizon, which according to the power analyses presented above, would likely provide statistically significant results at the local scale. Such sets of stations would not need to be operated indefinitely to achieve the targeted monitoring objective they were designed to address. Moreover, if a number of such hypothesis-driven sampling schemes were integrated through a CBM framework, the termination of a few of the stations, even after as few as 4-5 yr, would still provide important data for the broader-scale program, provided that new stations were initiated in similar habitats within the region of interest. This is, in large part, how the current MAPS program operates – as a collection of smaller scale studies. Until now, however, little direction has been given to the establishment of new stations in such a way as to maximize the ability of the program to address monitoring questions at broader spatial scales.

We also suggest, however, that collections of integrated hypothesis-driven sampling schemes for target species and habitats involving 20-yr time horizons, even when fully coordinated at regional and continental scales, may not provide all of the broad-scale, long-term needs of a coordinated demographic monitoring program. Priority species and habitats and specific hypotheses driving any current sampling scheme may need to change as new and unforeseen threats and environmental driving forces arise (e.g., through large-scale processes such as climate change, soil and water acidification, and airborne environmental contamination) that may affect or otherwise interact with efforts to monitor habitat-specific demographic rates or demographic effects of habitat management. We suggest that some level of spatially extensive, long-term "surveillance" monitoring should be a critical component of demographic monitoring efforts, and that some number MAPS stations be operated indefinitely across the continent. We further suggest that national parks, research natural areas, and other protected areas might be optimal for this monitoring, as they tend to be relatively pristine and not subject to complicating effects of on-going land management. It is also possible that researchers utilizing protocols other than that of MAPS to collect capture-recapture data on North American landbirds could also contribute to continental-scale demographic monitoring (provided that their within- and between-year time periods of data collection are sufficient). An additional future direction of MAPS may be the solicitation of such data and the development of analytical methods that integrate them with MAPS data.

Our final discussion addresses the fact that MAPS stations, in general, are not sited according to a probabilistic sampling strategy. Thus, inferences cannot be made beyond the sample of stations being considered for any particular analysis. While it might be useful to provide inferences regarding demographic parameters for specific geographical areas at various scales, the greatest value of MAPS lies in its ability to inform conservation by identifying demographic causes of population change, inferring ultimate ecological causes of population change by relating avian demographic rates to habitat and weather variables, and evaluating the effectiveness of management strategies designed to reverse population declines and enhance depressed populations. To optimize these processes, it is appropriate to site stations according to hypothesis-driven sampling strategies that, ideally, incorporate a probabilistic element as to the exact locations of the stations. This, in fact, is the manner in which many MAPS stations are sited.

Despite the non-random distribution of stations, program-wide (continental) MAPS population trends (lambda) have been shown to be correlated with survey-wide (continental) BBS population trends derived from randomlysited (albeit roadside) BBS routes (Saracco et al. 2008). Interestingly, MAPS trends tended to be slightly more positive than BBS trends, likely reflecting the fact that MAPS stations often cannot be operated in poor quality habitats, such as extensive agricultural fields and highly developed or urbanized areas, in contrast to BBS routes that often traverse those habitats. Thus, the distribution of stations resulting from multiple collections of hypothesis-driven sampling schemes across the continent may not be too unrepresentative of the overall environment, at least at the program-wide (continental) scale, and the trade-off in the ability to make inferences at large geographic scales in favor of inferences regarding the effectiveness of more local habitat management actions may not be very severe.

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APPENDIX 1. Effect sizes (%) currently detectable by MAPS with 80% power and 20 years of data for 47 species in the Northwest Region. Two effect types were considered: a two-population comparison of survival (2P) and a population with linearly declining survival (LD). Effect sizes are given for two alpha-levels, 0.10 and 0.20. Note that we do not propose an expanded but not targeted program in the Northwest. See Table 2 for major habitats, Table 3 for field definitions, and Tables 3 and 5 for scientific names.

							$\alpha = 0.10$		$\alpha = 0.20$	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD
Red-naped Sapsucker	PNC,WC,WR	28	370	36	0.366	0.544		20		20
Red-breasted Sapsucker	PNC,WC,WR	47	671	70	0.449	0.371		20		20
Hairy Woodpecker	PNC,WC,WOJ,WR	56	249	25	0.550	0.286		20	25	15
Western Wood-Pewee	PNC,WC,WR	54	1015	86	0.513	0.336	20	15	20	15
"Traill's" Flycatcher	SSD,WR	32	1115	77	0.524	0.460	20	15	15	10
Hammond's Flycatcher	PNC,WC	53	1142	105	0.453	0.404	20	15	15	15
Dusky Flycatcher	SSD,PNC,WC	47	1903	133	0.488	0.421	15	15	15	10
"Western" Flycatcher	PNC,WC	54	1681	118	0.481	0.314	20	15	15	15
Warbling Vireo	PNC,WC,WR	86	3560	306	0.479	0.422	10	10	10	10
Black-capped Chickadee	PNC,WC,WR	43	831	73	0.466	0.443	20	15	15	15
Mountain Chickadee	PNC,WC	41	891	60	0.471	0.414	25	15	20	15
Bewick's Wren	SSD,CSS	13	168	22	0.452	0.461		20	25	15
House Wren	SSD,WR	27	597	57	0.278	0.373				25
Winter Wren	PNC,WC	37	926	70	0.375	0.521	25	20	20	15
Ruby-crowned Kinglet	PNC,WC	14	628	50	0.255	0.275				25
Veery	PNC,WR	4	92	12	0.714	0.386		25	25	20
Swainson's Thrush	PNC,WC,WR	78	7394	856	0.586	0.629	5	5	5	5
Hermit Thrush	PNC,WC	35	808	66	0.461	0.537	20	15	15	15
American Robin	SSD,PNC,WC,WOJ,WR	116	3947	370	0.575	0.258	10	10	10	10
Varied Thrush	PNC	30	388	26	0.494	0.407		25		20
Wrentit	SSD,CSS	21	487	58	0.527	0.637	15	15	15	10
Gray Catbird	SSD,WR	12	584	51	0.561	0.450	15	10	15	10
Orange-crowned Warbler	SSD,WOJ	40	1468	94	0.481	0.418	20	15	15	15
Yellow Warbler	SSD,WR	49	4086	363	0.571	0.493	5	10	5	5
Yellow-rumped Warbler	PNC,WC	60	2906	217	0.486	0.208	20	15	15	15
Townsend's Warbler	PNC	23	823	82	0.451	0.216		20		20
American Redstart	WR	7	304	24	0.443	0.526		25		20
MacGillivray's Warbler	SSD,PNC,WC	85	5763	542	0.479	0.614	5	10	5	10

APPENDIX 1. Continued.

							α = 0.10		α = 0.20	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD
Common Yellowthroat	SSD	27	1452	153	0.499	0.556	15	10	10	10
Wilson's Warbler	SSD,PNC,WC	56	3638	265	0.438	0.526	15	10	10	10
Yellow-breasted Chat	SSD,WR	15	873	89	0.448	0.560	20	15	20	15
Western Tanager	PNC,WC	73	1386	100	0.538	0.129		20	25	15
Green-tailed Towhee	SSD,CSS	5	209	21	0.602	0.360		20	25	15
Spotted Towhee	SSD,WR,CSS	42	955	88	0.476	0.508	15	15	15	10
Savannah Sparrow	SSD	2	321	31	0.585	0.285	25	15	20	15
Fox Sparrow	SSD,PNC,WC	25	505	44	0.553	0.451	15	10	15	10
Song Sparrow	SSD.WR	98	5868	643	0.470	0.598	5	10	5	5
Lincoln's Sparrow	SSD,PNC,WC	37	2091	267	0.432	0.631	10	10	10	10
White-crowned Sparrow	SSD	14	598	61	0.474	0.544	20	15	15	15
Dark-eyed Junco	SSD,PNC,WC	83	5217	533	0.461	0.500	10	10	5	10
Black-headed Grosbeak	PNC,WC,WOJ,WR	68	2057	155	0.568	0.280	10	10	10	10
Lazuli Bunting	SSD,WR,CSS	25	1074	62	0.552	0.245	25	20	25	15
Red-winged Blackbird	SSD	18	799	42	0.784	0.148	15	10	10	10
Brown-headed Cowbird	SSD,WR	60	748	68	0.486	0.485	20	15	15	15
Bullock's Oriole	WOJ,WR	19	497	25	0.454	0.429		15	25	15
Purple Finch	PNC,WC	32	2386	155	0.434	0.364	20	15	20	15
American Goldfinch	SSD,WR	20	1434	108	0.470	0.328	20	15	15	15

APPENDIX 2. Effect sizes (%) currently detectable by MAPS with 80% power and 20 yrs of data, and likely detectable under an expanded MAPS program, for 42 species in the Southwest Region. Two effect types were considered: a two-population comparison of survival (2P) and a population with linearly declining survival (LD). Effect sizes are given for two alpha-levels, 0.10 and 0.20. See Table 2 for major habitats, Table 3 for field definitions, and Tables 3 and 5 for scientific names.

		Current									Expanded			
							α = 0.10		α = 0.20		α = 0.10		α = 0.20	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD	2P	LD	2P	LD
Red-naped Sapsucker	WC,WR	4	119	23	0.494	0.665	25	15	20	15	20	15	15	15
Nuttall's Woodpecker	WOJ,WR	16	195	28	0.551	0.381	25	15	20	15	20	15	15	15
Downy Woodpecker	SSD,WOJ,WR	20	217	24	0.605	0.431	20	15	20	15	15	10	15	10
Olive-sided Flycatcher	WC	2	55	3	0.870	0.724	25	20	20	15	15	10	10	10
Western Wood-Pewee	WC,WOJ,WR	15	278	27	0.384	0.446		25		20	25	20	25	15
"Western" Flycatcher	WC	15	892	43	0.595	0.183		25	25	20	25	15	20	15
Ash-throated Flycatcher	WOJ,CSS	31	676	80	0.659	0.137	15	15	15	10	10	10	10	10
Bell's Vireo	WR	5	112	15	0.482	0.596		20		15	25	15	20	15
Warbling Vireo	WC,WR	15	1253	52	0.539	0.460	20	15	20	15	15	10	15	10
Steller's Jay	WC	9	98	13	0.762	0.234			25		20	15	15	15
Black-capped Chickadee	WC,WR	7	110	17	0.366	0.600		25		20		20	25	15
Mountain Chickadee	WC	10	254	39	0.408	0.292		25		25		20	25	20
Chestnut-backed Chickadee	WC	6	259	41	0.501	0.512	25	15	20	15	15	15	15	10
Oak Titmouse	WOJ	11	153	18	0.514	0.358				25		20	25	15
Juniper Titmouse	WOJ	4	44	9	0.655	0.409				25	25	15	20	15
Bushtit	SSD,WOJ,CSS	30	975	171	0.300	0.152				25		25		20
Bewick's Wren	SSD,CSS	38	1047	137	0.424	0.538	15	15	15	15	15	10	10	10
House Wren	SSD,WOJ,WR	27	941	113	0.388	0.439	20	15	15	15	15	10	15	10
Swainson's Thrush	WC,WR	8	1819	121	0.619	0.578	10	10	10	10	5	10	5	5
Hermit Thrush	WC	9	410	75	0.450	0.400	25	15	20	15	15	15	15	10
American Robin	SSD,WC,WOJ,WR	27	706	90	0.529	0.309	20	15	15	15	15	10	15	10
Wrentit	SSD,CSS	16	838	106	0.540	0.618	15	10	10	10	10	10	10	10
Orange-crowned Warbler	SSD,WOJ	15	1076	79	0.413	0.318		20	25	20	20	15	20	15
Virginia's Warbler	SSD,WOJ	9	283	23	0.484	0.395		25		20		15	25	15
Yellow Warbler	SSD,WR	18	1097	110	0.479	0.526	15	10	15	10	10	10	10	10
Common Yellowthroat	SSD	22	1624	178	0.525	0.426	10	10	10	10	10	10	10	10
Wilson's Warbler	SSD,WC	9	2609	124	0.446	0.510	20	15	15	15	15	10	10	10
Yellow-breasted Chat	SSD,WR	17	750	108	0.522	0.521	15	10	15	10	10	10	10	10

APPENDIX 2. Continued.

		Current									Expanded			
							α = 0.10		α = 0.20		α = 0.10		α = 0.20	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD	2P	LD	2P	LD
Summer Tanager	WR	6	125	23	0.506	0.451		20	25	15	20	15	20	15
Spotted Towhee	SSD,WOJ,WR,CSS	36	1170	165	0.496	0.430	10	10	10	10	10	10	10	10
California Towhee	SSD	17	392	62	0.536	0.356	25	15	20	15	20	15	15	10
Fox Sparrow	SSD,WC	3	95	11	0.519	0.551				20		20	25	15
Song Sparrow	SSD,WR	26	2101	288	0.520	0.479	10	10	10	10	10	10	5	10
Lincoln's Sparrow	SSD,WC	3	112	18	0.437	0.876		20	25	20	20	15	20	15
Dark-eyed Junco	SSD,WC	8	336	49	0.387	0.560	20		25	15	20	15	20	15
Black-headed Grosbeak	WC,WOJ,WR	35	1684	157	0.526	0.345	15	15	15	10	10	10	10	10
Blue Grosbeak	WR	11	187	17	0.409	0.408				25		20		20
Lazuli Bunting	SSD,WR,CSS	21	643	41	0.372	0.473		20	25	20	25	15	20	15
Red-winged Blackbird	SSD	9	232	41	0.880	0.037			20		15		15	
Brown-headed Cowbird	SSD,WR	30	275	38	0.463	0.568	25	15	20	15	20	15	15	10
Bullock's Oriole	WOJ,WR	18	566	46	0.458	0.377	15		25	15	20	15	20	15
Purple Finch	WC	7	932	96	0.531	0.304	20	15	15	15	15	10	10	10

APPENDIX 3. Effect sizes (%) currently detectable by MAPS with 80% power and 20 yrs of data, and likely detectable under an expanded MAPS program, for 25 species in the North-central Region. Two effect types were considered: a two-population comparison of survival (2P) and a population with linearly declining survival (LD). Effect sizes are given for two alpha-levels, 0.10 and 0.20. See Table 2 for major habitats, Table 3 for field definitions, and Tables 3 and 5 for scientific names.

		Current									Expanded			
							$\alpha = 0.10$		$\alpha = 0.20$		$\alpha = 0.10$		$\alpha = 0.20$	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD	2P	LD	2P	LD
"Traill's" Flycatcher	SSD,NC,NH	12	649	49	0.484	0.509	20	15	20	15	15	10	15	10
Least Flycatcher	NH	12	847	68	0.368	0.431	25	20	20	15	15	15	15	15
Red-eyed Vireo	NH,SH	24	631	42	0.534	0.391		20	25	15	20	15	20	15
Black-capped Chickadee	NC,NH	28	654	50	0.417	0.394		25		20	25	20	20	15
Tufted Titmouse	NH,SH	10	163	17	0.555	0.407		20		20	20	15	20	15
House Wren	SSD	18	892	83	0.322	0.440		20	25	20	20	20	20	15
Veery	NH	9	390	45	0.575	0.586	15	10	10	10	10	10	10	10
Wood Thrush	NH,SH	12	263	31	0.453	0.317		20		20	25	15	20	15
American Robin	SSD,NC,NH,SH	26	787	39	0.380	0.423		25		25		20	25	20
Gray Catbird	SSD,NH,SH	23	2196	196	0.497	0.478	10	10	10	10	10	10	10	10
Yellow Warbler	SSD	15	1336	123	0.548	0.398	15	15	15	10	10	10	10	10
Chestnut-sided Warbler	SSD,NH	4	380	42	0.378	0.572		20	25	20	20	15	20	15
American Redstart	NH,SH	11	605	44	0.454	0.282		20	25	15	20	15	15	15
Kentucky Warbler	SH	2	88	12	0.610	0.698		15	25	15	20	15	15	10
Mourning Warbler	SSD,NC	3	122	15	0.421	0.608		25		25		20	25	20
Common Yellowthroat	SSD	24	1299	117	0.433	0.498	20	15	15	15	15	10	10	10
Field Sparrow	SSD	8	593	61	0.426	0.392		20		20	25	15	20	15
Song Sparrow	SSD	22	1137	117	0.444	0.517	20	15	15	15	15	10	10	10
Swamp Sparrow	SSD	6	201	14	0.386	0.776		25		20	25	20	25	15
White-throated Sparrow	NC	3	309	33	0.383	0.621		20	25	15	20	15	20	15
Northern Cardinal	SSD,NH,SH	18	603	50	0.539	0.355	25	15	25	15	20	15	15	15
Indigo Bunting	SSD	16	793	70	0.518	0.312	25	15	20	15	15	15	15	10
Brown-headed Cowbird	SSD	22	219	18	0.487	0.411				25		20	25	15
Baltimore Oriole	NH,SH	14	309	29	0.615	0.184				25	25	20	25	15
American Goldfinch	SSD	21	1635	164	0.347	0.360		20	25	20	20	20	15	15

APPENDIX 4. Effect sizes (%) currently detectable by MAPS with 80% power and 20 yrs of data, and likely detectable under an expanded MAPS program, for 22 species in the South-central Region. Two effect types were considered: a two-population comparison of survival (2P) and a population with linearly declining survival (LD). Effect sizes are given for two alpha-levels, 0.10 and 0.20. See Table 2 for major habitats, Table 3 for field definitions, and Tables 3 and 5 for scientific names.

		Current									Expanded			
							$\alpha = 0.10$		$\alpha = 0.20$		$\alpha = 0.10$		$\alpha = 0.20$	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD	2P	LD	2P	LD
Acadian Flycatcher	SH	6	349	27	0.583	0.478	20	15	20	15	20	15	15	10
White-eyed Vireo	SSD,SH	24	1380	117	0.601	0.498	10	10	10	10	10	10	10	10
Bell's Vireo	SSD	12	450	41	0.593	0.377	20	15	20	15	20	15	15	15
Red-eyed Vireo	NH,SH	15	328	30	0.575	0.221				25		25	25	20
Tufted Titmouse	NH,SH	24	318	36	0.486	0.296		20	25	15	25	15	25	15
Carolina Wren	SH,SC	31	888	79	0.459	0.517	15	15	15	10	15	10	15	10
Bewick's Wren	SSD	21	480	44	0.431	0.498		20	25	20	25	20	25	15
Gray Catbird	SSD,NH,SH	9	741	57	0.581	0.467	15	10	15	10	15	10	10	10
Brown Thrasher	SSD	15	288	15	0.408	0.572				25		25		25
Long-billed Thrasher	SSD,SBE	3	133	12	0.628	0.396				25		25		20
Blue-winged Warbler	SSD,SH	4	244	18	0.555	0.490	25	15	20	15	20	15	20	15
Yellow Warbler	SSD	3	103	13	0.353	0.515				25				25
Kentucky Warbler	SH	11	457	41	0.608	0.535	15	15	15	10	15	10	15	10
Common Yellowthroat	SSD	14	440	36	0.471	0.478	25	15	20	15	20	15	20	15
Yellow-breasted Chat	SSD	8	651	72	0.521	0.391	25	15	20	15	20	15	15	15
Summer Tanager	SH,SC	19	223	17	0.531	0.377				25		25		20
Olive Sparrow	SBE	3	208	24	0.510	0.738	20	15	20	15	20	15	15	15
Field Sparrow	SSD	31	1108	108	0.482	0.343	20	15	15	15	15	15	15	10
Northern Cardinal	SSD,NH,SH,SC	48	2475	245	0.581	0.356	10	10	10	10	10	10	10	10
Indigo Bunting	SSD	23	1181	111	0.459	0.422	20	15	15	15	15	15	15	10
Painted Bunting	SSD	31	1591	103	0.558	0.439	10	10	10	10	10	10	10	10
Brown-headed Cowbird	SSD	39	477	40	0.474	0.364		20	25	15	25	15	20	15

APPENDIX 5. Effect sizes (%) currently detectable by MAPS with 80% power and 20 yrs of data, and likely detectable under an expanded MAPS program, for 38 species in the Northeast Region. Two effect types were considered: a two-population comparison of survival (2P) and a population with linearly declining survival (LD). Effect sizes are given for two alpha-levels, 0.10 and 0.20. See Table 2 for major habitats, Table 3 for field definitions, and Tables 3 and 5 for scientific names.

		Current									Expanded			
							α = 0.10		α = 0.20		α = 0.10		α = 0.20	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD	2P	LD	2P	LD
Downy Woodpecker	NH,SH	49	414	28	0.445	0.525		25		20	25	20	25	15
“Traill's” Flycatcher	SSD,NC,NH	17	636	30	0.502	0.541	25	15	25	15	20	15	15	15
Eastern Phoebe	SSD,NH,SH	24	238	11	0.571	0.405				25		20	25	15
White-eyed Vireo	SSD,SH	13	295	37	0.479	0.396		20	25	15	25	15	20	15
Red-eyed Vireo	NH,SH	55	1459	130	0.582	0.295	10	10	10	10	10	10	10	10
Blue Jay	NH,SN	43	268	7	0.869	0.164	25		20		15		10	15
Carolina Chickadee	SH	19	187	9	0.484	0.449				25		20		20
Black-capped Chickadee	NC,NH	50	1099	114	0.514	0.294	20	15	15	15	15	10	10	10
Tufted Titmouse	NH,SH	36	411	51	0.393	0.298		25		20	25	20	20	15
Veery	NH	41	1792	244	0.577	0.574	10	10	5	10	5	5	5	5
Swainson's Thrush	NC	6	91	13	0.621	0.686	25	15	25	15	20	15	15	10
Hermit Thrush	NC,NH	21	328	47	0.457	0.631	20	15	15	15	15	10	10	10
Wood Thrush	NH,SH	53	1981	177	0.424	0.403	20	15	15	15	15	15	15	10
American Robin	SSD,NC,NH,SH,SC	54	1479	115	0.429	0.329	25	20	20	15	20	15	15	15
Gray Catbird	SSD,NH,SH	50	4849	495	0.515	0.460	10	10	5	10	5	10	5	5
Blue-winged Warbler	SSD,SH	18	352	26	0.442	0.387				25		25		20
Yellow Warbler	SSD	28	1268	108	0.509	0.475	15	10	15	10	10	10	10	10
Chestnut-sided Warbler	SSD,NH	18	459	47	0.475	0.527	20	15	20	15	15	15	15	10
Magnolia Warbler	NC	11	401	31	0.346	0.738		25		20	25	20	20	20
Yellow-rumped Warbler	NC	11	292	31	0.460	0.501	25	15	20	15	20	15	15	15
Black-thr. Green Warbler	NC,SC	17	337	39	0.402	0.589	25	20	25	15	20	15	15	15
Black-and-white Warbler	NC,NH,SH	40	667	72	0.502	0.301	25	15	20	15	15	15	15	10
American Redstart	NH,SH	36	1943	171	0.525	0.331	15	10	15	10	10	10	10	10
Worm-eating Warbler	SH	12	405	32	0.520	0.395		20		20	25	15	20	15
Ovenbird	NC,NH,SH	51	1752	166	0.557	0.425	10	10	10	10	5	10	5	5
Louisiana Waterthrush	SH	11	185	13	0.477	0.745		20	25	15	20	15	20	15
Common Yellowthroat	SSD	45	2263	209	0.502	0.493	10	10	10	10	10	10	10	10
Hooded Warbler	SH	15	499	45	0.460	0.610	20	15	15	15	15	10	10	10

APPENDIX 5. Continued.

		Current									Expanded			
							α = 0.10		α = 0.20		α = 0.10		α = 0.20	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD	2P	LD	2P	LD
Yellow-breasted Chat	SSD	7	214	22	0.501	0.356		25		20		20	25	15
Eastern Towhee	SSD,SC	35	543	61	0.489	0.331	25	15	20	15	20	15	15	10
Song Sparrow	SSD	37	1192	117	0.336	0.511	25	20	20	20	20	15	15	15
Swamp Sparrow	SSD	8	131	15	0.422	0.721		25		25		20	25	20
White-throated Sparrow	NC	14	537	58	0.289	0.583		20	25	20	20	20	20	15
Northern Cardinal	SSD,NH,SH,SC	41	826	76	0.618	0.365	15	15	15	10	10	10	10	10
Indigo Bunting	SSD	26	504	41	0.465	0.543	25	15	20	15	15	15	15	10
Red-winged Blackbird	SSD	20	471	24	0.587	0.320		20	25	15	20	15	15	15
Baltimore Oriole	NH,SH	22	305	18	0.418	0.476				25		20		20
American Goldfinch	SSD	39	1780	102	0.442	0.209		25		25		20	25	20

APPENDIX 6. Effect sizes (%) currently detectable by MAPS with 80% power and 20 yrs of data, and likely detectable under an expanded MAPS program, for 21 species in the Southeast Region. Two effect types were considered: a two-population comparison of survival (2P) and a population with linearly declining survival (LD). Effect sizes are given for two alpha-levels, 0.10 and 0.20. See Table 2 for major habitats, Table 3 for field definitions, and Tables 3 and 5 for scientific names.

		Current									Expanded			
							α = 0.10		α = 0.20		α = 0.10		α = 0.20	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD	2P	LD	2P	LD
Downy Woodpecker	NH,SH	61	381	16	0.620	0.344		25		20	25	15	20	15
Acadian Flycatcher	SH	47	1786	150	0.483	0.556	15	10	10	10	10	10	10	10
White-eyed Vireo	SSD,SH	43	1012	103	0.465	0.561	15	10	15	10	10	10	10	10
Red-eyed Vireo	NH,SH	56	2230	224	0.620	0.212	15	10	10	10	10	10	10	10
Carolina Chickadee	SH	65	569	44	0.493	0.282		20	25	15	20	15	20	15
Tufted Titmouse	NH,SH	67	948	93	0.511	0.434	15	15	15	10	10	10	10	10
Carolina Wren	SH,SC	65	1367	149	0.369	0.582	15	10	15	10	10	10	10	10
Wood Thrush	NH,SH	56	2635	258	0.455	0.552	10	10	10	10	15	15	15	15
Gray Catbird	SSD,NH,SH	25	1054	86	0.428	0.477	20	15	20	15	10	10	5	10
Blue-winged Warbler	SSD,SH	9	286	31	0.558	0.279	25	15	20	15	20	15	15	10
Worm-eating Warbler	SH	16	309	28	0.529	0.404		20		20	25	15	20	15
Ovenbird	NH,SH	46	1588	136	0.528	0.480	15	10	10	10	20	15	15	15
Louisiana Waterthrush	SH	19	295	31	0.520	0.516	25	15	25	15	10	10	10	10
Kentucky Warbler	SH	35	1232	137	0.507	0.600	10	10	10	10	10	10	10	10
Common Yellowthroat	SSD	41	1422	116	0.439	0.503	20	15	15	15	15	10	15	10
Hooded Warbler	SH	29	619	59	0.514	0.525	20	15	15	15	15	15	15	10
Yellow-breasted Chat	SSD	24	524	65	0.292	0.323				25		25		20
Eastern Towhee	SSD,SC	45	279	31	0.472	0.344		20		20	25	15	20	15
Song Sparrow	SSD	2	167	15	0.410	0.520				25		25		20
Northern Cardinal	SSD,NH,SH,SC	69	2105	237	0.543	0.392	15	10	10	10	10	10	10	10
Indigo Bunting	SSD	47	1220	120	0.521	0.306	20	15	15	15	15	10	10	10

APPENDIX 7. Effect sizes (%) currently detectable by MAPS with 80% power and 20 yrs of data, and likely detectable under an expanded MAPS program, for 19 species in the Alaska/Boreal Canada Region. Two effect types were considered: a two-population comparison of survival (2P) and a population with linearly declining survival (LD). Effect sizes are given for two alpha-levels, 0.10 and 0.20. See Table 2 for major habitats, Table 3 for field definitions, and Tables 3 and 5 for scientific names.

		Current									Expanded			
							$\alpha = 0.10$		$\alpha = 0.20$		$\alpha = 0.10$		$\alpha = 0.20$	
Species	Major habitat(s)	Sta	Ind	Res	$\hat{\phi}$	$\hat{p}$	2P	LD	2P	LD	2P	LD	2P	LD
"Traill's" Flycatcher	SSD	13	584	28	0.383	0.506		25		20	20	15	20	15
Black-capped Chickadee	BH	10	244	28	0.426	0.401				25		20	25	20
Boreal Chickadee	BC	10	132	16	0.492	0.365				25	25	15	25	15
Arctic Warbler	SSD	2	249	25	0.339	0.605		25		25	25	20	25	20
Gray-cheeked Thrush	SSD,BC	6	253	27	0.459	0.683	25	15	20	15	15	10	15	10
Swainson's Thrush	BC	16	837	76	0.456	0.590	15	10	15	10	10	10	10	10
Hermit Thrush	BC,BH	9	611	57	0.499	0.766	15	10	15	10	10	10	10	10
Orange-crowned Warbler	SSD	16	1324	96	0.413	0.504	20	15	20	15	15	10	10	10
Yellow Warbler	SSD	9	1114	80	0.445	0.456	25	15	20	15	15	10	10	10
Yellow-rumped Warbler	BC,BH	16	680	48	0.367	0.432		20	25	20	15	15	15	15
American Redstart	BH	2	256	21	0.571	0.308		20	25	15	15	15	15	10
Northern Waterthrush	SSD,BC	9	213	15	0.528	0.725		15	25	15	15	15	15	10
Wilson's Warbler	SSD,BC	15	2861	182	0.366	0.565	15	15	15	10	10	10	10	10
Canada Warbler	BH	2	149	14	0.462	0.475		20		25	25	15	20	15
American Tree Sparrow	SSD	7	199	15	0.483	0.500		20		25	20	15	20	15
Fox Sparrow	SSD	13	391	31	0.518	0.556	25	15	20	15	15	10	15	10
White-crowned Sparrow	SSD	13	626	65	0.435	0.412		20		20	20	15	15	15
Golden-crowned Sparrow	SSD,BC	5	279	30	0.533	0.490	25	15	25	15	15	15	15	10
Dark-eyed Junco	BC,BH	15	630	67	0.309	0.636		20	25	20	15	15	15	15