MoSI Operations Manual

Instructions for establishing and operating bird-banding stations as part of the Monitoreo de Sobrevivencia Invernal program

Hooded Oriole, Yucatán. Photo by Becky Matsubara

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Revised September 2021

ACKNOWLEDGMENTS

MoSI protocols were developed in collaboration with many individuals, including T. Scott Sillett, Rodney Siegel, Alexis Cerezo, and Borja Míla. In the U.S. and Latin America, elements or geographies of the MoSI program have been coordinated by various individuals including Peter Pyle, Claudia Romo, Salvadora Morales, Alexis Cerezo, Mariamar Guitierrez, Lety Andino, José Luís Alcántara, Manuel Grosselet, Said Felix, Juan Carlos Fernández Ordóñez, Elma Kay, Liliana Chavarria Duriaux, Georges Duriaux, Marvin Torrez, and others. This manual is modeled, in large part, on the MAPS (Monitoring Avian Productivity and Survivorship) Manual. We are grateful to Kenneth M. Burton, Pilar Velez, Danielle Kaschube, and Dan Froehlich for their efforts in helping to produce that document. Nicole Michel adapted MAPS databases, verification programs, and data sheets for use in the MoSI program. Gabe David, Kelly Gordon, and Peter Pyle helped with updating recent versions of the manual.

We thank an anonymous donor to The Institute for Bird Populations for seed money to initiate the MoSI Program, and the March Conservation Fund for more recent sustained funding. The U.S. Department of Defense Legacy Resource Management Program provided funding to investigate non-breeding season survival of landbirds on Naval Station Guantanamo Bay, a project that paved the way for the creation of the MoSI Program. Financial support for the MoSI program has been provided by funding from the U.S. Fish and Wildlife Service through the Neotropical Migratory Bird Conservation Act. The University of California, Los Angeles has provided support through grants from the Ecology of Infectious Disease program of NIH/NSF and from UC-Mexus.

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We are extremely grateful to the many organizations, biologists, and volunteers that have established and operated MoSI stations.

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The Bird Genoscape Project
The Calgary Bird Banding Society
The Cornell Lab of Ornithology
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Windsor Research Centre
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Zumbro Valley Audubon

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The MoSI program has flourished through the efforts of hundreds of biologists, administrators, and volunteers from the southern U.S. and the Neotropics. We thank all for their hard work and dedication to bird conservation across the Americas. Pictured here are the participants in one of the first MoSI trainings, in Nicaragua in 2002. Standing, at rear: Freddy Ramirez, David DeSante, Liliana Chavarria-Duriaux; Seated, middle row: Alejandra Martínez-Salinas, Mariamar Gutiérrez, Sergio Vílchez-Mendoza, Sandra Hernández, Peter Pyle, Salvadora Morales (standing); Seated, front row: Heydi Herrera, Marvin Tórrez, Edgar Castañeda, Osmar Arróliga, Georges Duriaux (front).

In 2020, several MoSI cooperators and others participated in a molt and bird identification training in Nicaragua at Reserva Privada Concepción de María. The meeting included three participants from the meeting 18 years earlier. (Can you find them?). Standing, from left to right are: Ismael López, George Duriaux, Liliana Chavarría Duriaux, Marlon Sotelo, Ariel Salinas, Perla Laguna Hammond, Juan Cruz Gámez, Oswaldo Saballos, Alejandro Velásquez, Consuelo

Chamorro de Rapaccioli, Reyna Peña, Roger Mendieta, Juan Cruz Rodríguez, Oscar Bermúdez Collado, Vincent Romera, Claudia Julissa Mendoza, Eduardo Medina, Marvin Torrez. Personas agachadas de izquierda a derecho: Adonis Cruz, María Angélica Almendarez, Aldo Rapaccioli.

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1. Introduction

1.1 An Invitation

Welcome to the MoSI (Monitoreo de Sobrevivencia Invernal=Monitoring Overwintering Survival) Program! MoSI is a cooperative effort among public agencies, private organizations, and independent bird banders in Mexico, Central America, South America, and the Caribbean to better understand spatial- and habitat-related variation in the non-breeding season physical condition and survivorship of migratory landbirds. To achieve this goal, MoSI relies on data collected between November and March at a network of standardized mist-netting and banding stations across the non-breeding ranges of these species. We encourage all individuals currently conducting or planning work on migratory landbirds in the northern Neotropics to become partners in the MoSI Program. By becoming a MoSI cooperator, you can help identify proximate causes of population change in these species, which can help guide efforts for their management and conservation.

Contributing to the MoSI Program is relatively easy, and we have taken a number of steps to facilitate the establishment and operation of new stations. First, we designed the program to allow variations on the basic field protocol. None of the protocol variations require more than 15 days of mist-netting per MoSI season (November to March). Second, we encourage banders to try to find training or mentorship opportunities between existing and prospective MoSI cooperators. IBP also provides micro-grants to defray the cost of equipment, and an annual Fellowship Program to enable one early-career MoSI biologist to attend training and information exchange with IBP in the U.S. We also actively seek funding and support for the program and for individual stations through grant writing and the development of partnerships with U.S.-based conservation organizations.

While it is relatively easy to become a MoSI cooperator, station operation does require considerable attention to detail and a commitment to the safe collection of quality data. This manual will guide prospective cooperators through each step involved in the establishment and operation of a MoSI station. Should you become a MoSI station operator, we recommend that you consult this manual frequently to ensure that your data are collected and reported in a way that will allow for the attainment of program goals.

If you are interested in establishing one or more MoSI stations in your region or would like additional information, please contact Steven Albert, MoSI Program Coordinator (salbert@birdpop.org), Said Felix (MoSI Mexico Coordinator, saidfelix@gmail.com), or Juan Carlos Fernández Ordóñez (MoSI South America/Caribbean Coordinator, pvaa.ve@gmail.com).

Thank you for your interest in MoSI – we look forward to working with you in our efforts to better understand and conserve migratory landbird populations!

1.2 BACKGROUND AND RATIONALE

Analyses of data from the North American Breeding Bird Survey (BBS) and other sources indicate that populations of many species of Neotropical migratory birds (NTMBs) have declined over the past three decades (Robbins et al. 1989, Peterjohn and Sauer 1993, Pardiek and Sauer 2000; Rosenberg et al. 2019). To work collaboratively to reverse bird population declines, conservation professionals from across the Americas have established initiatives such as the Neotropical Migratory Bird Conservation Initiative, Partners in Flight, and the North American Bird Conservation Initiative. Often, however, conservation is hindered by a lack of information concerning the proximate (demographic) and ultimate (environmental) causes of declines (DeSante 1992, 1995, Peterjohn et al. 1995, DeSante et al. 2001, Bellier et al. 2018). Although the BBS and other programs provide information on geographic- and habitat-related variation in bird abundance and population trends, these may not provide sufficient information about where and when in the annual cycle population pressure is acting most strongly.

By contrast, vital rates (productivity, recruitment, survivorship, emigration, immigration) respond directly and usually without substantial time lags to environmental stressors or management actions (Temple and Wiens 1989, DeSante and George 1994). The estimation of avian vital rates provides critical information to population managers and should be an integral component of all avian monitoring and management efforts (DeSante and Rosenberg 1998). In the case of NTMBs, estimates of vital rates can help determine whether population declines are related to low productivity on the breeding grounds, high mortality during migration or non-breeding, or both (Sherry and Holmes 1995, 1996, DeSante et al. 2001). These estimates can be incorporated into predictive population models to assess potential effects of land use practices (Noon and Sauer 1992) or model the effects of climate change (Nott et al. 2002).

The Institute for Bird Populations (IBP) initiated the first large-scale efforts to measure and monitor vital rates of NTMBs in 1989 with the creation of the Monitoring Avian Productivity and Survivorship (MAPS) Program (DeSante et al. 1995). Each summer, public agencies, private organizations, and individuals across the U.S. and Canada operate hundreds of standardized constant-effort mist-netting and bird-banding stations as part of this program. These efforts are paying off and yielding important insights into the proximate causes of NTMB population change across North America (see DeSante et al. 2018 and many other MAPS-related publications at https://birdpop.org/pages/maps.php). Results from the MAPS Program (DeSante et al. 2001, Nott et al. 2002) and from intensive local-scale studies (Marra et al. 1998, Sillett et al. 2000) suggest that the conditions experienced by NTMBs during the non-breeding season affect population dynamics and could limit populations.

NTMBs spend the bulk of the year on their non-breeding grounds. Yet, data on the non-breeding season ecology of most NTMBs is severely limited. A variety of local-scale studies have shown that many NTMBs use a wide array of habitats in the tropics; even species thought to prefer relatively mature or undisturbed primary forest can be found in substantial numbers in secondary forest, forest edge, and other disturbed habitats (e.g., Greenberg 1992). Patterns of

non-breeding season abundance in different habitats, however, can be a misleading indicator of habitat quality (Marra and Holberton 1998). In order to determine the true value of different non-breeding habitats, estimates of sex-, age-, and habitat-specific non-breeding season survival rates and indices of non-breeding season physical condition are needed. These parameters have only been studied for a few species on local scales (e.g., Marra et al. 1998, Sillett et al. 2000, Sillett and Holmes 2002). In order to draw inference for a larger suite of species, and to determine how these parameters vary as a function of space and habitat, a standardized spatially extensive monitoring effort is required. These data are critically needed to evaluate the quality of various non-breeding habitats for NTMBs and to guide NTMB management and conservation efforts (Latta et al. 2003).

The MoSI program concentrates its effort on Neotropical **migratory birds** (the program was started with funding dedicated to this objective). For several years, we have been exploring the possibility of expanding efforts to **resident birds**, and it's likely the program will include these in the future. For now, IBP lacks the funding and labor capacity to handle this effort. However, we encourage banders to take data on all birds they mist net and band.

1.3 Design and Objectives of the MoSI Program

To begin providing data on the quality of habitats for NTMBs during the non-breeding period, the first 29 MoSI stations were established and operated during 2002-03 as part of a five-year pilot project (DeSante et al. 2005). Funding from the Neotropical Migratory Bird Conservation Act (NMBCA) enabled expansion of the program in the second year of the pilot project (2003-04) to 63 stations. The MoSI program is patterned after, and is designed to complement, the highly successful MAPS program. Both programs (1) call for the establishment of a spatially-extensive network of standardized banding stations, (2) address clear monitoring goals based on firmly established needs, and (3) use state-of-the-art analytical models for making inferences at multiple spatial and temporal scales.

The Monitoring Goal of MoSI is to provide estimates of monthly, seasonal, and annual survival and indices of physical condition for Neotropical migratory landbirds in a variety of habitats and geographic regions.

The Research Goals of MoSI include the statistical modeling of survival and physical condition as functions of age, sex, habitat, geography, and climate; linking of winter population parameters with breeding season vital rates and population trends; and development of predictive population models.

The Management Goals of MoSI are to use research results to develop strategies for reversing population declines and maintaining healthy populations; and to evaluate management actions through an adaptive management framework.

The Development Goals of MoSI are to provide training and capacity building for, and the production of, bird conservation research and publications.

The establishment of the MoSI network has also facilitated the collection of feathers for genetic analyses that link breeding and non-breeding populations – a key component in understanding the full annual cycle dynamics of migratory birds. The MoSI Program currently has a cooperative agreement with the Bird Genoscape Project, an effort to map the population-specific migratory routes of 100 species of migratory songbirds by harnessing the power of genomics. Identifying these migratory connections provides an effective tool for monitoring declining populations and for developing effective conservation strategies. The project was conceived and initiated Dr. Thomas Smith of UCLA and is currently directed by Dr. Kristen Ruegg of Colorado State University. More information about the project, including information on how to participate in provided in Section 7.

1.4 Administration of the MoSI Program

The MoSI program is administered by IBP which coordinates activities with several regional coordinators, including Raul Said Quintero Felix (Mexico), Elma Kay (Belize), and Juan Carlos Fernández Ordóñez (South America and the Caribbean Region). Frequent feedback to cooperators is provided by regional coordinators.

1.5 MoSI Regions

We have delineated 15 regions as organizational units for the MoSI program, based on EPA Level I Ecoregions (www.epa.gov/eco-research/ecoregions) with slightly modified boundaries to encompass biomes that made sense from a biological and programmatic perspective.

2. Establishing a MoSI Station

2.1 What is a MoSI Station?

A MoSI **Station** is a discrete study site with a core netting area of approximately 12 ha and a buffer extending 50 m beyond the core area. An idealized MoSI station is a 20 ha square (~ 450 m on a side) with a core area measuring ~350 m on a side and containing 16 mist nets (Fig. 2). MoSI stations can, however, be a variety of shapes (e.g., linear stations along riparian corridors), as long as the core netting area (12 ha) and net density (~1.33 nets/ha) remain similar to that of the idealized station. In some cases, two stations can be located nearby to one another (< 1 km) to create one 40 ha "superstation".

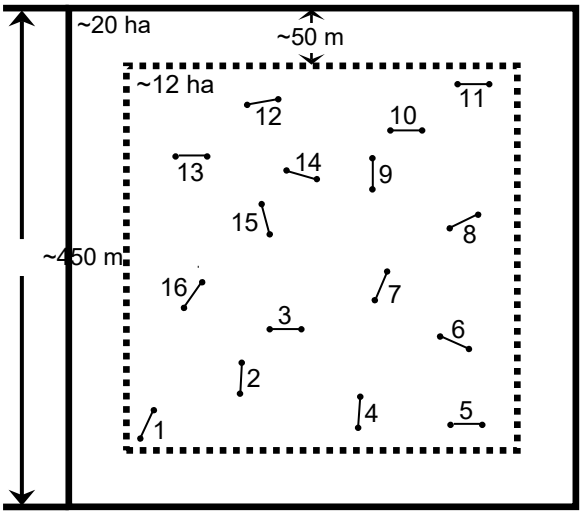

Figure 1. An idealized MoSI station.

Each MoSI **Station** is identified by a unique name and 4-character code (e.g., Cafetál de Sombra=CAFE or CASO). Numbers may be used to distinguish contiguous or nearby stations that make up a "superstation" e.g., Cafetál 1=CAF1 and Cafetál 2=CAF2. Each station is also identified by a **Location** name and code that reflects the larger landscape or landholding (e.g., national park or nature reserve) within which the station is located (e.g., Reserva Natural de Mombacho=MOMB). A **Location** may contain multiple stations operated by the same organization. If only one station is operating, the **Location** and the **Station** may have the same four-letter code.

2.2 Siting the MoSI Station

The ability of large-scale monitoring efforts such as the MoSI Program to provide unbiased measures of population parameters depends, to some extent, on how study sites are selected. Ideally, all stations should be sited randomly on the landscape. For example, a researcher interested in cloud forest habitat might randomly select coordinates from a map and site their station as near as possible to that random point. In reality, such a strategy will be constrained by factors including land ownership, accessibility, etc. Target species could also be rare at randomly selected sites, limiting their utility as monitoring sites. We ask that cooperators attempt to meet as many as the following site selection criteria as possible:

Factors to consider when selecting a MoSI station site

- Choose sites likely to catch substantial numbers of Neotropical migratory birds.
- Select sites with habitats representative of the surrounding landscape.
- Choose sites containing at least some edge habitat (forest gaps, trails, roadsides, early successional areas, etc.). Sites dominated by forest interior should have areas with a well-developed understory that is utilized by target species.
- Choose sites likely to remain accessible and free of major **anthropogenic** disturbance for at least five years (disturbance from fire, habitat succession, and other factors may occur in the larger landscape).
- Do not site MoSI stations in areas with artificial food or water sources (feeders, compost piles, dumps, fountains, livestock pens).
- Avoid siting stations less than 1 km from one another, to minimize multiple captures of the same individual at multiple stations.

2.3 Setting Up the MoSI Station: Mist Nets

Once a suitable site has been found for the MoSI station, operators must determine the size, number, and placement of mist nets.

Net Size: Mist nets used in the MoSI program should be 12-m, four-tiered, black, tethered, nylon nets. Shorter (6- or 9-m nets) nets can be used; however, care should be taken to record these as partial nets when calculating effort (see Section 5.1). The mesh size of nets should be **30 mm**.

NET NUMBER: Operators should run the maximum number of nets that can be safely and efficiently operated on a regular basis. Ideally, this will be **16 nets** (or a net density in the core area of approx. 1.3 nets/ha; Figure 1). However, stations with high capture rates or few personnel **may run fewer**. Operators should always place the welfare of the birds as their primary concern when deciding how many nets to run.

NET PLACEMENT: A good strategy for placing the nets is to locate them singly and relatively uniformly over the core netting area (> 50 m from the station boundary). Nets should be placed in areas likely to catch substantial numbers of birds (e.g., in brushy portions of wooded areas, forest breaks or edges, or in the vicinity of water). An alternate strategy is to place nets along two or more transects that traverse the station and are separated by at least 150 m. Each net site should be uniquely identified by a number (2-digit maximum).

Many cooperators take time to scout an area for several days or weeks to find the best habitat. Also, some use the first year of the project to "test" an area. If your site is not catching many migratory birds, it's better to move it to an area that catches more than continue with a non-productive site.

Summary of Mist Net Set-up

- Use black, 12-meter, 30mm mesh nets
- Run the maximum number of nets you safely can (generally 10-16)
- Place nets opportunistically in areas likely to catch birds (brushy portions of wooded areas, forest edges, or near water)
- Separate nets by at least 150 meters whenever possible

3. MoSI Station Registration

All MoSI cooperators must complete a MoSI Station Registration Form for each station operated and submit it (via e-mail) to IBP. Registration forms are available at: https://birdpop.org/pages/mosiDataForms.php.

The form provides contact information and information on the station's location, habitat, and intended operations, including:

Station Manager Contact Information: The station manager is the contact person for the MoSI program. Please notify IBP of changes in contact information.

Additional Station Operator Contact Information: You may provide contact information for a second individual with station responsibilities. Secondary operators may be staff biologists,

technicians, or volunteers who play a role in station operations field work. Both the Station Manager and secondary operators can be included on regional MoSI mailing lists.

Location Code: A unique, four-letter code you select to designate your station or set of stations.

Station Code: A unique, four-letter code you select to designate your station. For single-station locations, this is typically the same as the location code. Use numbers to distinguish adjacent stations that are part of a "superstation" (e.g., CAF1, CAF2).

Station Name: The full name of your station; please try to keep to four words or fewer.

Funding Sources: List the government agencies, NGOs, and foundations that support your station, or "private" if the station is self-financed.

Land Ownership: The organization that owns the property where the station is located. If it is government owned, indicate the agency, state, or city that owns the land, or put "private".

Nearest Town: Indicate the nearest community that shows up on most maps.

Latitude and Longitude: Please provide the latitude and longitude coordinates in decimal degrees for the approximate center of the station.

Mean Elevation: The mean elevation of the station, in meters.

Approximate Size of Study Area: Ideally, stations should be 20 ha with a core area of 12 ha.

Habitat Description: Provide a brief summary of the station's vegetation, e.g., mature lowland rain forest, cloud forest, deciduous second-growth woodland, shade coffee plantation, etc.

Target Species (expected): List the Neotropical migratory species you expect to capture.

Number of 12-m mist nets: We recommend an approximate net density of 1.33 nets/ha.

Number of pulses station is expected to be operated: This is normally five (once per month from November through March), but can be as few as three. If fewer than five pulses are operated, indicate which pulses the station will be operated.

Number of days of operation per pulse: Should be three days, though it can be two days for 5-pulse or 4-pulse stations.

Create a station map of the study area: Create a map of the station (study area) with Google Earth, GIS, or another format. Be sure to include a scale and an arrow indicating North (if it's not toward the top of the page). Draw the boundary of the station, which should extend at least 50m beyond the outermost nets and should total about 20 ha. Label, as appropriate, the

boundaries between major habitat types, net locations and orientations, and bodies of water roads, trails, and human-made structures.

In addition to the above information, station operators should submit an accompanying letter describing special circumstances, anticipated difficulties, or proposed deviations from protocols outlined in the MoSI manual. As indicated on the registration form, a map showing the geographic location of the station should also be submitted.

4. Operating a MoSI Station

The MoSI program is designed to be inclusive, and is flexible enough to accommodate protocol variations. We suggest every effort be made to apply a consistent protocol at your station in all years of operation, which can aid in modeling of survival rates. We appreciate, however, that changes can often be necessary as funding, staffing levels, or research objectives change.

4.1 General Station Operation

4.1.1. Basic Field Protocol. The basic MoSI field protocol calls for five monthly pulses, with each pulse consisting of banding on two or (preferably) three consecutive days, for a total of 10-15 banding days in a 5-month period (see table below). Pulses should be as close to the midpoint of each of the five periods as possible, though this may be difficult during bad weather or for those operating multiple stations. A 5-day grace period is permitted at the start or end of each period. For example, Pulse 1 (normally November 1-30) could be started as early as 26 October or completed as late as 5 December. Try to have consecutive pulses separated by at least three weeks (the minimum acceptable interval between pulses is two weeks).

MoSI Banding Pulses

When weather or logistics prevent completion of a banding pulse within a particular period, the pulse can begin as much as five days before or completed as much as five days after the defined period.

Pulse 1	November 1 – November 30
Pulse 2	December 1 – December 31
Pulse 3	January 1 – January 31
Pulse 4	February 1 – February 29
Pulse 5	March 1 – March 31

Due to weather, budgets, shortage of personnel, or other reasons, some MoSI cooperators may be unable to complete five pulses of banding during the MoSI season. Stations that cannot be operated for five pulses should be operated for at least three (and preferably four) pulses. For stations operating during only three pulses, we recommend one pulse be conducted during

November or December (early season) and one pulse be conducted during February or March (late season) to ensure coverage during both the early and late non-breeding periods. The following schedules are acceptable:

Nov.-Dec.-Feb.	Nov.-Jan.-Feb.	Nov.-Jan.-Mar.
Dec.-Jan.-Feb.	Dec.-Jan.-Mar.	Dec.-Feb.-Mar

Other alternatives are permitted but less desirable. Stations operating for only two pulses may not be able to be included in survival analyses.

4.2 Net Operation and Banding

MoSI stations should be operated for at least 6 hours per day, with the goal of beginning at sunrise, or more hours if conditions and staffing permit; afternoons can often be quite productive. If high temperatures, lack of shade, rain, wind (> 10 knots or gusts > 20 knots), or logistical considerations prevent this, every effort should be made to operate during at least the first 4-6 morning hours. Missed effort should be as minimal as possible, with the goal of completing at least **12 hours of banding during a pulse.** In general, days of operation within a pulse should consecutive whenever possible. Nets should be opened and closed and checked in the same order each day. Net opening and closing times should be recorded to the nearest ten minutes (see Section 5.1).

4.3 Color Banding and Resighting

Color banding and resighting, though labor intensive, can provide an excellent means for improving the precision of survival-rate estimates. Although resighting may be difficult at stations with dense vegetation, we urge station operators with sufficient time and personnel to consider color banding and resighting one or more focal species. If you are interested in setting up a re-sighting protocol, please contact IBP.

5. Summary of Mist-netting Effort

The **Summary of Mist-Netting Effort** is an essential part of the MoSI protocol and provides information that can be used in mark-recapture analyses. Please fill out this form carefully and double-check your net-hour calculations (see example below). Summary of Mist-netting Effort forms can be obtained from regional coordinators or downloaded at https://birdpop.org/pages/mosiDataForms.php.

5.1 Completing the Summary of Mist-Netting Effort Form

Location, Station: Record the four-character codes for your Location and Station.

Year: Record the current non-breeding season (e.g., 2021-22).

List net numbers of all 12-m nets: Indicate net-site number designations for all 12-m nets.

List net numbers and lengths of all other nets: Record the net designations and lengths of all other nets. If you do not operate other length nets, record **N/A** or **none**.

Intended Pulse: Indicate the pulse number for the day's effort.

Date: Record the month and day of operation for each day in each pulse (dd/mm).

Date recording conventions differ between the United States and Canada, where the "month-day-year" format is most common, and much of the rest of the world, which typically uses a "day-month-year" format. Beginning in 2021, we will begin using the latter convention. For example, **3 January 2021** should be recorded as **03/01/22** *not* 01/03/21.

Net numbers: Record net numbers for all nets operated. A single day's effort should be recorded on multiple lines if nets of different sizes are used or if the nets are open for varying periods of time. For example, if 16 nets were opened at 0700 and nets 08 and 09 were closed at 1000 due to sun or wind, the effort should be recorded on at least two lines.

Open Time and Close Time: Using the 24-hr clock, record, to the nearest 10 minutes, the opening or closing time of the first net opened or closed.

Net Hours: Record the net hours accumulated (to the nearest 0.01 net hour) for each line.

Pulse Net Hours: Record the total effort for all days in a pulse on the last line for the pulse.

Note No.: Record a note (with a number) on the reverse side of the form indicating why nets were opened or closed at times that deviate from the standard protocol.

Sample Effort Sheet

MoSI Summary of Mist-netting Effort - Page 1

Location Code: _____ **Station Code:** _____ **Season:** 2021-22

List net-site numbers of all 12-m nets:

List net numbers and lengths (in meters) of all other nets:

Pulse 1: Nov. 1 – Nov 30
Pulse 2: Dec. 1 – Dec. 31
Pulse 3: Jan. 1 – Jan. 31
Pulse 4: Feb. 1 – Mar. 1
Pulse 5: Mar. 1 – Mar. 31

Intended Pulse	Date (dd/mm)	Net-site number(s)	Open Time (nearest 10 min.) hour	minute	Close Time (nearest 10 m.) hour	minute	Net Hours	Pulse Net Hours	Note No.*
e.g., 1	*03/12*	*01-08, 10-16*	*06*	*0 0*	*18*	*0 0*	*168.00*		
<	*<*	*09*	*06*	*30*	*18*	*00*	*11.50*		*1*
<	*04/12*	*01-16*	*06*	*00*	*18*	*00*	*180.00*		
<	*05/12*	*01-09, 13-16*	*06*	*00*	*12*	*00*	*78.00*		
<	*<*	*10-12*	*08*	*00*	*12*	*00*	*12.00*	*449.5*	*2*
				0		0			
				0		0			
				0		0			
				0		0			
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				0		0			
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				0		0			
				0		0			
				0		0			
				0		0			
				0		0			

6. Collecting and Recording Banding Data

All unbanded birds captured at MoSI stations should be identified to species and, with the possible exception of very small (e.g., hummingbirds) and very large (e.g., large raptors) birds, be banded with uniquely-numbered metal bands.

MoSI Program regional coordinators can assist in the acquisition of bands for use on migratory and Neotropical resident species. In addition to banding, it is critical that the age and sex of all birds (including recaptures) be determined to the greatest extent possible. With practice, fine-scale age and sex determination is possible for most NTMB species (see Bird Banding Offices 1991, Pyle 1997, Froehlich 2003).

Unfortunately, few references exist for ageing and sexing Neotropical resident bird species, though several have been published recently:

Resources for Understanding Molt in Tropical Birds:

Torrez and Arendt 2017. La Muda en especies de aves selectas de Nicaragua [Molt in selected species of Nicaraguan birds.] UCA Publicaciones. Available **HERE** or in the IBP Publications Database.

Johnson and Wolfe 2018. Molt in Neotropical Birds: Life History and Ageing Criteria. More information **HERE.**

Pyle et al. 2015. Manual for ageing and sexing landbirds of Bosque Fray Jorge National Park and north-central Chile, with notes on occurrence and breeding seasonality. Available **HERE** in English and **HERE** in Spanish.

We encourage MoSI station operators to collect as much ancillary data on resident species as possible (data on plumage, molt, eye color, skull pneumaticization, breeding condition, etc.) to begin filling this data gap.

6.1 General Procedures for Recording Banding Data

6.1.1. MoSI Banding Data Sheets.—All banding data should be recorded in the field on copies of the 8 1/2" × 14" MoSI banding data sheets. There are three data sheets:

- The **MoSI Banding Sheet** for recording newly banded birds
- The **MoSI Recaptures Sheet** for recording recaptures
- The **MoSI Unbanded Sheet** for recording birds that are captured but left unbanded

Banding data sheets can be downloaded at https://birdpop.org/pages/mosiDataForms.php.

6.1.2. Recording Data in the Field. Although submission of hard copies of data sheets is not required, we recommend some general guidelines when recording data in the field:

(1) **Record data in black ink.** Data recorded in other ink colors or pencil does not photocopy well, and pencil marks can fade easily. Errors should be fixed by applying correction tape or a fast-drying correction fluid and then correcting the data. Writing over incorrectly entered data can result in confusion during computer data entry.

(2) **Keep separate sets of MoSI Banding Sheets for each residency class.** That is, birds banded with USGS bands (migrants) and birds banded with non-USGS bands (residents). If using non-USGS bands for all birds, it's still a good practice to use separate data sheets.

(3) **Fill out all heading fields** (Location, Year, Band Size, Page #) on all data sheets. Be sure to enter the location code exactly as on your registration form. Fill in Year with the current non-breeding season (e.g., 2021-22). If you are using different band strings for migrant and resident birds, indicate which band string is being used in the Band Size field (e.g., "M-1B" for migrant birds of band size 1B, while "R-1B" might be entered for residents).

(4) **Number pages sequentially for each band size/residency status combination**, starting with page 1 each year. This will allow you to see at a glance how complete your data set is. By writing "End of Year" at the bottom of the last page of each band size/residency combination, you can further ensure that you have a complete set for the season.

(5) **Do not use separate band strings and data sheets for multiple stations** at a location UNLESS these stations are operated simultaneously (i.e., by different banders on the same day). By keeping all records for a band string together, you will facilitate data entry and avoid gaps in the band sequences on the data sheets. If more than one set of banding-data sheets (per residency status) must be used, use a different page-numbering sequence for each set (e.g., A1, A2, etc. for station 1; B1, B2, etc. for station 2).

(6) **Write out the first record of each day completely** then use (>) or (<) symbols in the BANDER'S INITIALS, SPECIES NAME, STATUS, DATE, CAPTURE TIME, and STATION fields if the entry is repeated on the same day and on the next line. Do not use ditto marks (") that can be mistaken for #1's. Do not use these symbols in any other fields.

(7) **Leave blank fields for which no data are collected.** Do not use zeroes, hyphens, slashes, or other symbols to designate blank. Record all data taken, even when values are "0".

6.1.3. Non-MoSI Data. Birds captured and banded outside of MoSI stations (e.g., birds trapped at feeding stations) or outside of the MoSI season *should not* be banded with USGS bands and *should not* be submitted as part of the MoSI Program.

6.1.4. NEWLY BANDED BIRDS. To ensure that band numbers are recorded correctly, it is important that original banding data for only a **single string of bands** be included on any **single MoSI Banding Sheet** and that the bands be used and recorded in sequence. This makes it much easier to detect when a band is missing, or what the next number in a string to be used is. As indicated above, records for non-USGS bands should be recorded on a different set of banding sheets than the set being used to record birds banded with USGS bands.

6.1.5. LOST AND DESTROYED BANDS. Lost and destroyed bands should be recorded in sequence on MoSI Banding Sheets. Record only CODE, BAND NUMBER, SPECIES NAME as "Band Lost" or "Band Destroyed," DATE, and STATION (see section 6.2 for banding field definitions).

6.1.6. RECAPTURES. Recaptured birds are recorded on the MoSI Recaptures Sheet. Every capture of a banded bird is a "recapture." Thus, recaptures include returns (first captures in a given period at a given station of birds banded at the same station in a previous period), repeats (subsequent captures, even on the same day, of birds banded or recaptured at the same station earlier in the period), and recoveries (first captures of birds banded at a different station or on a different permit). Birds banded outside of the MoSI season and recaptured during MoSI operation are also considered recaptures. Previously banded birds that escape or are inadvertently released before the band number is read should also be recorded as recaptures. Recaptured birds should receive CODE=R. Complete data should be taken for all recaptures and recorded only on MoSI Recaptures Sheets. It is crucial that new and recapture banding data NOT be entered on the same sheets. **Do not separate recaptures by band size**.

6.1.7. CHANGED BANDS. If a band is replaced, record the capture on both the MoSI Banding Sheet (new band) and MoSI Recaptures Sheet. Record the old band number on the Recapture Sheet, with the new number as a note on the back. Record the new band number on the Banding Sheet, with the old number as a note on the back. If the old band is unreadable, it should be sent to IBP. Both records should be given CODE=C. Never re-use a band you have taken off a bird; it makes tracking individuals difficult and increases injury risk to the bird. Changed bands should be counted only as recaptures on the Summary of Mist-netting Results (see section 8.1).

6.1.8. ADDED BANDS. Occasionally, birds wind up with a band on each leg, usually the result of a bander not realizing that a bird is already banded. This can be avoided by ensuring that all banders are banding on the same leg. If both bands are readable and neither is endangering the bird's welfare, it is best not to attempt to remove one of the bands. If the bird was captured with two bands, enter a record for each band, both with CODE=A (for Added Band), on the Recapture Sheet. If you have applied the second band, record it (again as CODE=A) on the Banding Sheet, with the original band number in a note, and record the original band on the Recapture Sheet (with code A) with the added band number in a note (analogous to changing a band, except that no band was removed). As with changed bands, added bands should be counted only as single recaptures on the Summary of Mist-netting Results (see section 8.1).

6.1.9. UNBANDED BIRDS. As much information as possible should be recorded on the MoSI Unbanded Sheets for birds that are captured but not banded (escapes, releases, and

mortalities). These data, although not used directly in MoSI analyses, allow us to more accurately gauge capture rates. A bird is considered an "escape" if it was touched prior to escape; a bird that bounces out of or escapes from a net before it is touched should not be recorded. "Releases" might include individuals of a species that a bander is not authorized to band or birds for which the recommended band size is unavailable.

6.1.10. MORTALITIES. Even when all reasonable precautions are taken, mortalities occasionally occur in the course of mist netting. If a bird dies before it is banded, it should be recorded on the MoSI Unbanded Sheet. If a bird dies just after it is banded, remove and destroy the band, record **the bird** on the MoSI Unbanded Sheet, and record ***the band*** on the MoSI Banding Sheet as destroyed (enter D in the CODE field; see section 6.2). Dead birds should receive 000 in the STATUS field and a D or P in the DISP field for "death due to cause other than predation" or "predator-caused mortality," respectively. If the mortality is a recapture, it should be recorded on the MoSI Recaptures Sheet and its band should be removed and destroyed (unless it is a recovery; that is, a migratory bird that was banded at some other station or on some other permit, in which case it should be reported to the BBL on form 3-1807 or, if you are operating as a sub-permittee under IBP's banding permit, should be reported to IBP to report to the BBL). As before, enter 000 in the STATUS field and D or P in the DISP field.

6.2 BANDING DATA FIELD DEFINITIONS, CODES, AND SCALES

Some contributors to the MoSI Program have used slightly different codes and scales in the past or with other programs. We strongly encourage MoSI cooperators to adopt the codes presented here. These codes are the result of thousands of hours of field work and subsequent analysis by researchers. If you do not adopt these scales and codes, you must provide an explanation of how your codes correspond to MoSI codes so that they can be converted for incorporation into the MoSI database.

Front of the banding-data sheet: The front of all MoSI banding data sheets is comprised of 38 fields, each with one or more columns.

BANDER'S INITIALS – Initials of the bander or person recording the data. Initials and full names of all banders on the page must be written at the bottom of the banding data sheet.

CODE – Capture Code. Use codes shown at the top of the banding data sheet:

N – Newly banded bird (see section 6.1.4)

L – Lost band (see section 6.1.5)

D – Destroyed band (see section 6.1.5)

R – Recaptured bird (see section 6.1.6)

S – Resighted bird (see section 6.1.7)

C – Changed band (see section 6.1.8)

A – Added band (see section 6.1.9)

U – Unbanded (see section 6.1.10)

BAND NUMBER – For new, lost, and destroyed bands, enter the complete band number for the first band on the first line of each page. DO NOT use a hyphen to separate the prefix from the rest of the band number. For USGS bands, three-digit prefixes should be preceded by a "0" (e.g., 972 should be recorded as '0972'). Two-digit prefixes should be preceded and followed by a zero (e.g., 81 should be recorded as '0810'). Resident bands with fewer than nine digits should be right-justified and preceded by zeros. Thus, all band numbers will be nine characters long. Please double-check to be sure that the first band number on each MoSI Banding Sheet is correct. After the first record has been entered on a MoSI Banding Sheet on a given day, only the last 3 digits of subsequent bands (right justified) need be recorded on that day. By entering the complete number only for the first record on a particular day, you can easily delineate records on different days and save time when entering data in the field.

For all recaptures, be sure to enter the full band number for all records. **PLEASE DOUBLE-CHECK** the band numbers of all recaptured birds before releasing them – incorrectly recorded band numbers are one of the largest sources of error we encounter and are detrimental to mark-recapture analyses. The reading of band numbers can be aided with some sort of optical magnification device. **For unbanded birds**, leave BAND NUMBER blank.

SPECIES NAME – Enter at least an abbreviation of the species name. We prefer that English or scientific names be used for this field (see www.birdpop.org/AlphaCodes). Species names (or abbreviations) will not be entered in the MoSI database but will serve as a check against the SPECIES ALPHA CODE (below), which is often error-prone. Write "Band Lost" or "Band Destroyed" in this space where appropriate (see 6.1.5).

SPECIES ALPHA CODE – Four- or, preferably, six-letter alpha codes should be entered in this field to indicate the species. A list of species alpha codes for all species can be downloaded at: www.birdpop.org/AlphaCodes. Four-letter codes are based on English names (e.g., Orange-crowned Warbler=OCWA) and largely follow codes long used by the BBL. Six-letter codes are derived from scientific names (e.g., *Leiothlypis celata*=LEICEL), which may be preferred by bird banders in Latin America. Occasionally, notes associated with a record indicate that the species determination for a recapture or an unbanded bird was uncertain. Mark these records by recording "QS" in the NOTE NUMBER field. A small proportion of alpha codes are updated once per year in July to correspond with taxonomic and name changes by the American Ornithological Society. Updated codes along with a list of all changes can be downloaded each year from www.birdpop.org/AlphaCodes.

AGE – The MoSI program allows either the calendar-year system developed by the BBL or the Wolfe-Ryder-Pyle (WRP) system for recording the age of birds. Typically, the calendar-based system works well with NTMBs, but for resident birds, MoSI operators should become familiar with the WRP system. Once this system is learned we encourage its use for NTMBs as well.

Excellent information on the WRP System can be found in Wolfe et al. 2010 and Johnson et al. 2011. For the calendar-based system, use these codes:

4 – **Local:** A young bird incapable of sustained flight. These birds should always be banded, processed, and released near the capture net as quickly as possible.

2 – **Hatch Year (HY)**: A bird capable of sustained flight and known to have hatched during the calendar year in which it is captured.

1 – **After Hatch Year (AHY)**: A bird known to have hatched before the calendar year in which it is captured; year of hatching otherwise unknown.

5 – **Second Year (SY)**: A bird known to have hatched in the calendar year preceding the year in which it is captured

6 – **After Second Year (ASY)**: A bird known to have hatched earlier than the calendar year preceding the year in which it is captured (known to be at least in its third calendar year); year of hatching otherwise unknown.

7 – **Third Year (TY)**: A bird known to have hatched two calendar years prior to the year in which it is captured (known to be in its third calendar year).

8 – **After Third Year (ATY)**: A bird known to have hatched more than two years prior to the year in which it is captured (known to be at least in its fourth calendar year); year of hatching otherwise unknown.

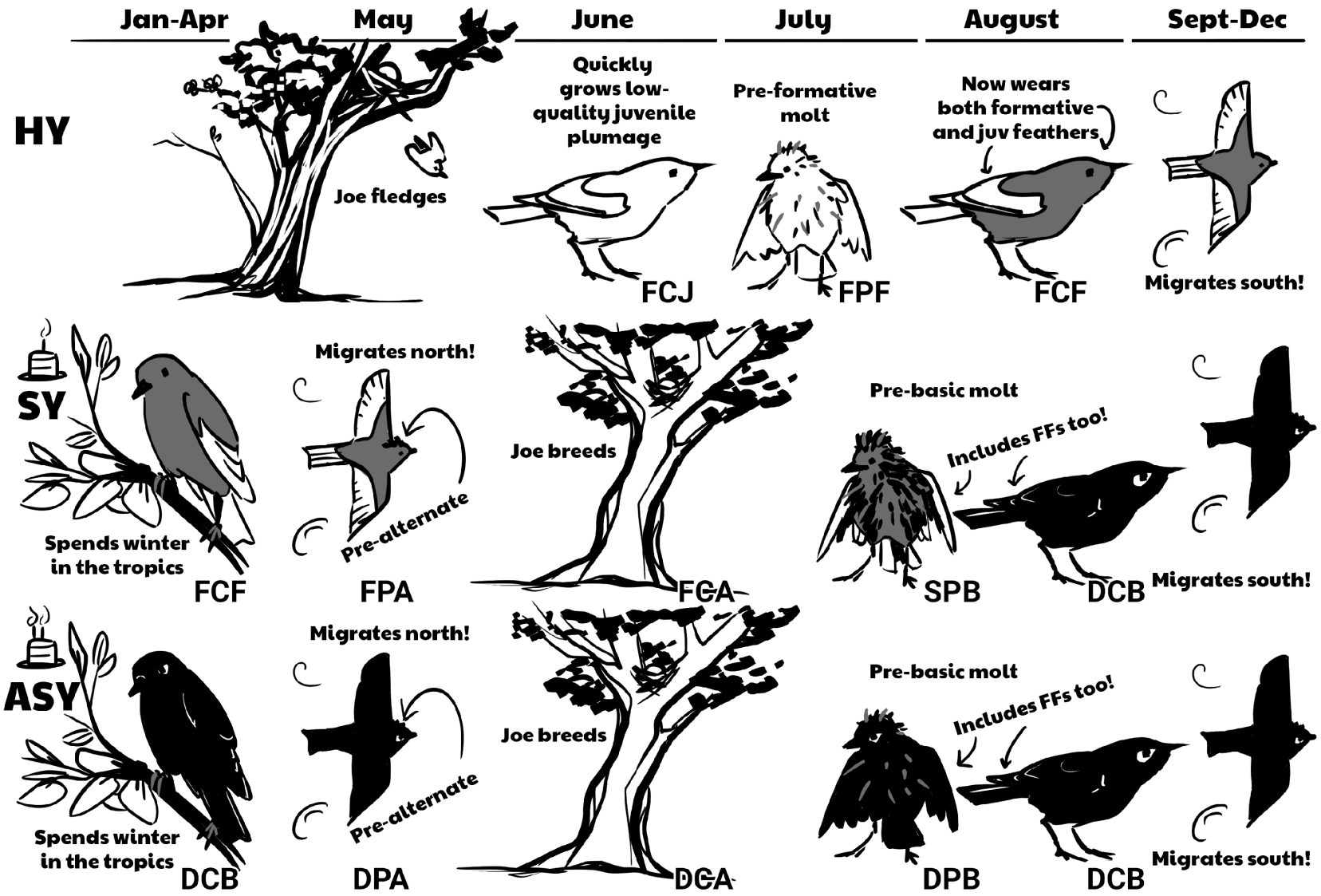
0 – **Indeterminable**: Age determination was attempted but not possible with confidence.

9 – **Not attempted:** Age determination was not attempted.

Please attempt (without relying on previous capture data) to age all NMTBs captured before 1 January as HY (AGE=2) or AHY (AGE=1) and all NMTBs captured after 31 December as SY (AGE=5) or ASY (AGE=6) (See diagram on the next page). Some near-passerines (including woodpeckers) and a few passerines can be aged to TY (AGE=7) and ATY (AGE=8). Note that when ageing birds by fine-scale criteria, such as the MOLT LIMITS AND PLUMAGE fields (see below), it is possible that various feather tracts may show conflicting characteristics (i.e., characteristics that indicate different age classes). When making an age determination, give more weight to feather tracts that are more reliable or have the most obvious diagnostic features. Although it is not necessary that all feather tracts in a record agree, you should be confident in your ultimate age designation. A bird with no diagnostic feather tracts or for which conflicting characteristics make age determination uncertain should be aged as indeterminable (AGE=0) prior to Jan. 1 or AHY after Dec. 31.

The diagram on the following page shows how to apply age codes from the calendar-based and WRP systems to a typical NTMB.

Three Years in the life of Joe Bird



For the **WRP system,** use these codes:

Pos. 1	Definition	Pos. 2	Definition	Pos. 3	Definition
F	First Molt Cycle	**C**	Not Molting	**J**	Juvenile Plumage
S	Second Molt Cycle	**P**	Molting	**F**	Formative Plumage
T	Third Molt Cycle	**U**	Unknown if molting	**B**	Basic Plumage
D	Definitive Molt Cycle			**A**	Alternate Plumage
U	Unknown Molt Cycle			**U**	Unknown Plumage

The most common WRP Codes used during banding include:

FAJ - After first cycle juvenile. The bird does not have any juvenile feathers but it can't be determined if it is in formative or basic plumage - **OR** - for known adults (by skull, breeding condition, etc) but in unknown plumage.

FPJ - First prejuvenile molt, molting into juvenile plumage.

FCJ - First cycle juvenile plumage, in full juvenile plumage, only juvenile feathers are present.

FPF - First preformative molt, molting into formative plumage.

FCF - First cycle formative plumage, in full formative plumage, mix of juvenile and formative feathers.

FPA - First prealternate molt, molting into first alternate plumage.

FCA - First cycle alternate plumage, full alternate plumage, a mixture of juvenile, formative and alternate feathers.

SPB - Second prebasic molt, molting into definitive basic plumage. Some juvenile, formative or first alternate feathers retained as contrast to the new basic feathers.

DCB - Definitive cycle basic plumage, full basic plumage.

DPA - Definitive prealternate molt, molting into definitive alternate plumage.

DCA - Definitive cycle alternate plumage, full alternate plumage, mix of basic and alternate feathers.

The codes FPA, FCA, DPA, and DCA will be used most often on NTMBs but are not common for resident species in the tropics. Other codes that may be used include SCB and TPB (for some woodpeckers and other non-passerines), and "unknown codes" such as UPU, UUU, FCU, and DCU. The latter two codes should be used only used for birds that can undergo prealternate molts, largely NTMBs.

HOW AGED – This field indicates the criteria used to determine age, whether or not the calendar-based or WRP ageing systems are used. Two codes should be used whenever possible. They should be entered from left to right in their order of importance in your age determination. You must record at least one criterion unless the age is unknown (i.e., unless age=0 or 9). Please study the banding sheet to better understand how this field should be used. Use only the codes listed at the top of the banding data sheets. Note that additional details concerning fine-scale ageing (i.e., distinguishing HY/SY, AHY/ASY, SY/TY, and ASY/ATY birds) will be provided in the MOLT LIMITS AND PLUMAGE fields (see below). Please do not age recaptures based on previous captures. Each capture should be treated in the field as if it were a new bird in order to avoid perpetuating previous errors and to enable us to see what is possible at that time of year.

Valid codes for HOW AGED include:

S – **Skull:** Degree of skull pneumaticization.

C – **Cloacal Protuberance:** Presence indicates an adult bird of a resident species.

B – **Brood Patch:** Presence indicates an adult bird of a resident species.

J – **Juvenile Plumage:** The presence of juvenile **body plumage** indicates a young bird. This should not be used to indicate the presence of retained juvenile flight feathers or coverts.

L – **Molt Limit:** The presence of two generations of feathers within a feather tract (e.g., within greater coverts) or between adjacent tracts (e.g., between primary coverts and greater coverts). If this code is used, at least one of the first seven **Molt Limits and Plumage** fields must be filled in.

P – **Plumage:** The appearance of plumages **other than** juvenile body plumage. Feather color and shape are plumage characteristics; measurements are not. Contrast in color or shape between two generations of feathers or groups of feathers should generally be treated as a molt limit characteristic, not a plumage characteristic. If this code is used, at least one of the first seven MOLT LIMITS AND PLUMAGE fields must be filled in.

M – **Molt:** The presence and characteristics of molt, indicated by pinfeathers or missing flight feathers in a symmetric pattern.

F – **Feather Wear:** The degree, if reliable, of flight-feather wear.

I – **Mouth/Bill:** The external and/or internal appearance, if reliable, of the bill or the presence of a fleshy gape on very young birds.

E – **Eye color:** The color of the iris, if reliable. This does not include the eye ring.

O – Other: Any criterion not listed above (e.g., date, wing length, tail length, orbital apterium, talon-flange serration, tail fork, etc.). If you use this code, you must explain how the bird was aged in a note on the back of the sheet.

SEX – A single-digit alpha code indicating the sex of the bird. Acceptable codes include:

M – Male.
F – Female.
U – Indeterminable. Sex determination was attempted but was not possible with certainty.
X – Not attempted. Sex unknown because sex determination not attempted.

HOW SEXED – Use the codes below as in HOW AGED above. As with age, do not sex recaptures in the field based on previous captures.

Valid codes for HOW SEXED include:

C – Cloacal Protuberance. The presence of a cloacal protuberance indicates an adult male.

B – Brood Patch. The presence or degree of a brood patch, if reliable, indicates adult female.

J – Juvenile Plumage. The appearance of juvenile body plumage.

P – Plumage. The appearance, if definitive, of all plumages after juvenile plumage.

I – Mouth/Bill. The appearance, if reliable, of the bill.

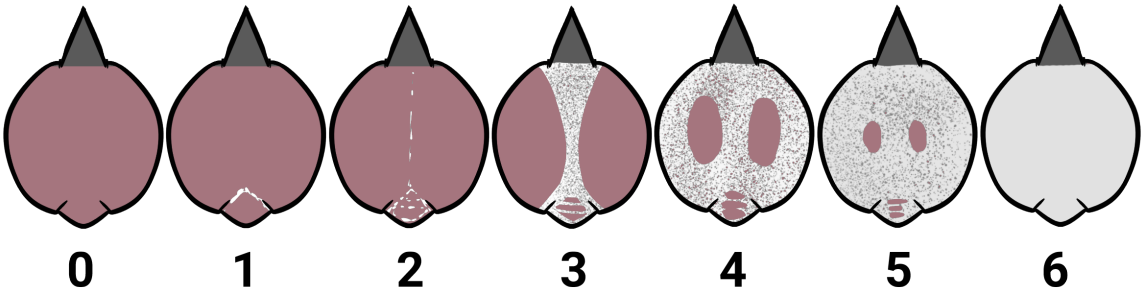
E – Eye Color. The color, if reliable, of the iris.

W– Wing Length. The wing chord, if reliable.

T – Tail Length. The length, if reliable, of the tail.

O – Other criterion (singing, tail fork, egg in oviduct, etc.). This code requires an explanatory note.

SKULL – **Skull Pneumaticization.** A fully pneumaticized skull consists of two layers of bone connected by tiny "struts" and filled with air, much like a plane wing. It appears opaque, gray and has tiny white dots. An un-pneumaticized skull has a single, thin layer of bone and appears pinkish and translucent, and never has tiny white dots. Skulls that are partially pneumaticized will have color contrast between these two regions. To determine degree of pneumaticization, it is necessary to part the head feathers (wetting them slightly may help) and gently move the skin over the skull. It is best to start at the back of the skull and proceed forward, looking for the line that separates the pneumaticized area from the un-pneumaticized area. Although the skulls of many small passerine species can become fully pneumaticized as early as October 1, the time at which the last individuals complete skull pneumaticization is unknown for many NTMBs. We recommend skulling as many birds as possible to help fill this data gap.



SKULL PNEUMATICIZATION should be recorded according to this scale (see also diagram below):

0 – **Skull not pneumaticized.** A single, thin layer of bone covers the brain, which shows through the thin covering of bone and appears unmarked and pinkish. This is found only in very young juveniles. Beware of thick-skinned species such as corvids and parids, whose skull can be difficult to see because the skin tends to be opaque; and heavily-muscled species such as grosbeaks and cardinals, whose jaw muscles can obscure the rear of the skull.

1 – **Skull 1–5% pneumaticized.** A trace of skull pneumaticization can be seen at the very back of the skull, usually appearing as an opaque, grayish crescent or a very-small, triangular area.

2 – **Skull 6–33% pneumaticized.** Skull less than 1/3 pneumaticized but some is obvious. The posterior part of the cranium has an inverted u- or v-shaped area of pneumaticization that is distinctly grayish and contrasts with the unpneumaticized area. The grayish area typically shows the small, whitish dots of a pneumaticized skull.

3 – **Skull 34–66% pneumaticized.** Typically, most of the rear half of the skull is pneumaticized, as is a small portion from the front to the back of the eyes (this is difficult to see because the feathers of the forehead are dense, short, and difficult to move out of the way). In most cases, a bird given a "3" will show a pneumaticized area extending up the midline or sides of the skull.

4 – **Skull 67–94% pneumaticized.** Skull at least 2/3 pneumaticized but small areas of skull are not pneumaticized. Unpneumaticized areas are usually seen as two oval, pinkish spots on either side of the cranium or, rarely, a single pinkish spot in the center of the skull.

5 – **Skull 95–99% pneumaticized.** Birds have a nearly fully-pneumaticized skull that shows one or two tiny, dull pinkish spots. Some birds, including many flycatchers, thrushes, and vireos, never develop fully pneumaticized skulls, even as adults. A "5"-skull cannot be reliably used for ageing birds.

6 – **Skull pneumaticization complete.** Skull opaque, grayish, with white dots; no pinkish spots evident.

8 – **Pneumaticization extent not visible.** Do not use if you have determined that pneumaticization is incomplete but are unsure of the appropriate score; in this case, make your best guess!

CL. PROT. – **Cloacal Protuberance (CP).** The MoSI season may overlap with the breeding seasons of some tropical resident species. As the breeding season approaches, the cloaca of male birds of most species begins to enlarge and form an obvious bulge where sperm are stored. Thus, this field (and BR. PATCH, below) will only be useful for sexing resident species.

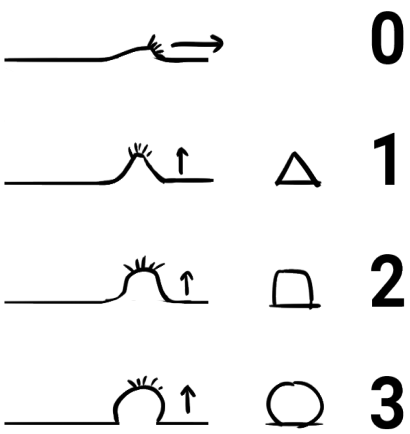
The development of the **CLOACAL PROTUBERANCE** should be scaled as follows:

0 – **None**. Cloaca not enlarged.

1 – **Small**. Cloaca somewhat enlarged, swollen, and wider at the base than near the tip (conical). Since small CPs can be hard to discern, caution should be used in ageing or sexing birds based solely on the presence of a CP of 1.

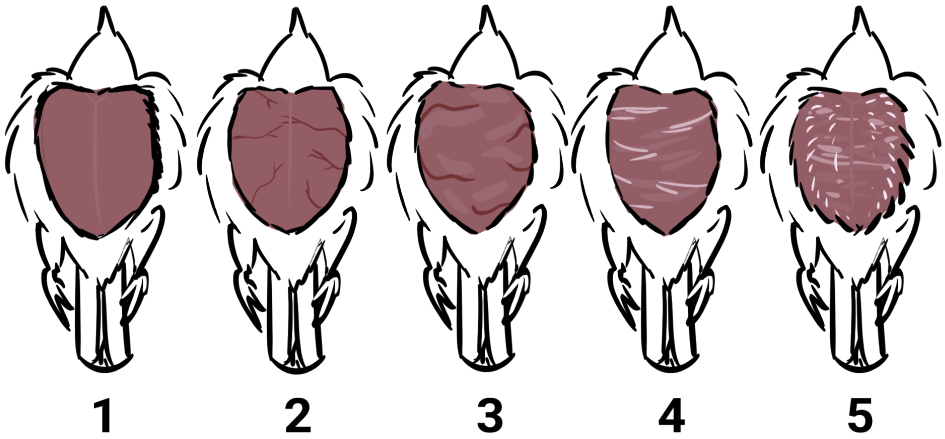
2 – **Medium**. CP large, with a diameter fully as large near the tip as at the base (cylindrical).

3 – **Large**. CP very large and with a diameter much larger in the middle than at the base (bulbous).



Unlike a brood patch (BP, see below), a regressing CP simply goes back down the scale: 3-2-1-0. CPs vary greatly in size and shape among species; for example, being large and prominent in sparrows and thrushes and less prominent in jays and flycatchers. It is possible to sex individuals of some species that rarely show prominent CPs by examining the angle of the CP with respect to the body axis. In males of these species, the CP seems to point straight out, more or less perpendicular to the body axis, while females have cloacas that point more to the rear, such that they are more parallel to the body axis. Because of this difference in orientation, some females with slightly enlarged cloacas can be separated from males with class-1 CPs. Male class-2 and class-3 CPs cannot be confused with female cloacas in any species. Please note that all cloacas, whether enlarged or not, stick out. A true CP is characterized by firmness and lateral swelling. Immature birds DO NOT get CPs.

BR. PATCH – Brood Patch. The MoSI season may overlap with the breeding seasons of some tropical resident species, thus this field (and CL. PROT., above) will only be used for tropical resident species. Just prior to and during egg incubation, females, and males of some species, develop a brood patch. Brood patch development involves feather loss, increased vascularization, and fluid accumulation just beneath the skin of the lower breast and abdomen. The purpose of these changes is to facilitate heat transfer from parent to eggs.. The sequence of 0 to 5 is symmetric: classes 1 and 5 resemble each other, class 5 being distinguished by the growth of new feathers. Classes 2 and 4 resemble each other, with class 4 distinguished by its dry, thin wrinkles, as opposed to the thick, fluid-filled wrinkles of class 2. In hummingbirds and juveniles of most species, the lower breast and abdomen are normally unfeathered. This can look like a brood patch of 1 or 4, but the area is darker red and unwrinkled and usually has a less distinct margin.



The development of the **BROOD PATCH** should be scaled as follows:

0 – None. No brood patch present, lower breast and abdomen mostly feathered. Unfeathered areas of the breast and abdomen are smooth, without evident vascularization.

1 – Smooth. Lower breast and abdomen feathers dropped and some vascularization evident, but most of the area rather smooth and dark red.

2 – Vascularized. Vascularization evident, some wrinkles present, and some fluid under the skin, giving the area a pale, opaque, pinkish color (as opposed to the normal, dark-red muscle color).

3 – Heavy. Vascularization is extreme; the brood patch becomes thickly wrinkled, and much fluid is present under the skin. This is the maximum extent of the brood patch and corresponds closely to the time during which the bird is incubating eggs.

4 – Wrinkled. Vascularization and fluid mostly gone. The skin, however, retains many thin, dry-looking, contracted wrinkles.

5 – Molting. Vascularization and fluid and most of the wrinkles are gone. Pinfeathers are present as the area begins to become re-feathered. Most birds do not reach class 5 BPs until the nesting season is over and the prebasic molt has begun.

FAT – **Fat Content.** Subcutaneous fat is a yellow or orange substance that is stored just under the skin and is used as fuel for migratory flights and for maintenance during the non-breeding months. Fat is generally stored in three discrete areas that usually fill in the following order: (1) the hollow in the furculum (wishbone) just below the throat at the top of the breast muscles; (2) the hollow directly under the wing, essentially in the "wing pit"; and (3) the lower abdomen just anterior to the vent area. Stored fat can be seen clearly through the nearly-transparent skin and contrasts with the dull, dark-reddish color of the breast muscles. It is seen most easily by holding the bird on its back while placing the index and middle fingers on the front and back of the bird's neck, stretching the head slightly forward along a line parallel to the body, and gently blowing the feathers away from the upper breast to expose the furculum. Then check under the wing and on the abdomen, again by blowing the feathers gently out of the way.

The codes below should be used to assess **FAT** accumulations.

0 – None. No fat in the furculum or anywhere on the body.

1 – Trace. A small amount (< 5% filled) of fat in the furcular hollow, but not enough to cover the bottom of the furculum, and none or just a trace on the wing, abdomen, or elsewhere on the body; **or**, if no fat in the furcular hollow, more than a trace of fat under the wing, on the abdomen, or both.

2 – Light. The bottom of the furculum completely covered but the furcular hollow less than 1/3 filled, and a small amount of fat under the wing, on the abdomen, or both; **or**, if no fat in the furcular hollow, a covering pad of fat definitely present under the wing pit and, usually, on the abdomen.

3 – Half. The furcular hollow about half full (from 1/3 to 2/3 filled), and a covering pad of fat definitely present under the wing pit and, usually, on the abdomen; **or**, if no fat in the furcular hollow, a thick layer of fat under the wing and on the abdomen.

4 – Filled. The furcular hollow full (from 2/3 full to level with the clavicles), and a thick layer of fat under the wing and on the abdomen; **or**, if the fat in the furcular hollow not full, the fat under the wing and on the abdomen well mounded.

5 – Bulging. The furcular hollow more than full, with fat bulging slightly above the furculum. Fat under the wing and on the abdomen also well mounded.

6 – Greatly bulging. Fat bulging greatly above the furculum. Large mounds of fat under the wings and on the abdomen.

7 – Excessive. Fat pads of the furculum, "wing pit," and abdomen bulging to the extent that they join. Nearly the entire ventral surface of the body with fat, extending onto the neck and head.

Fat classes 5-7 are seen most often just prior to and during migration.

BODY MLT – **Body Molt.** Body molt should be determined by examining the bases of all the contour feathers on the bird's body, including the upper- and underwing coverts (both secondary coverts and primary coverts) and the upper- and undertail coverts. The bases of feathers can be exposed by blowing lightly (but continuously) over the body. The presence of pinfeathers is a sign of the early stages of molt. Later stages can be recognized by a remnant, scaly sheath at the base of each growing feather. These sheaths persist until the feathers are fully grown. You should integrate a number of factors in making your rating, including the number of feather tracts in molt and the proportion of feathers in molt in each feather tract.

BODY MOLT should be rated according to the following scale:

0 – None. No body molt. No feathers in sheath or growing. Can include birds with 1-2 pin feathers (likely adventitiously replaced) but check with the IBP banders on this.

1 – Trace. Only a very few feathers molting anywhere on the bird's body, usually in no discernible pattern.

2 – Light. A few feathers are molting from a few feather tracts or some feathers (less than 1/2) are molting from only one tract. In general, less than 1/3 of the contour feathers are molting.

3 – Medium. Some feathers (generally less than 1/2) are molting from most tracts or many feathers (generally more than 1/2) are molting from one tract or a few tracts. In general, from 1/3 to 2/3 of a bird's contour feathers are in molt. This class also should be used for a bird in spring whose pre-alternate molt normally includes only the head but that has nearly all head feathers in molt. Such a bird would be given a class "3" even though less than 1/3 of all its contour feathers are molting.

4 – Heavy. Many feathers (generally more than 1/2) are molting from many or most tracts. In general, 2/3 of the contour feathers on the bird are in molt.

FF MOLT – **Flight-feather Molt.** "Flight feathers" is a collective term for primaries, secondaries, and rectrices, but when recording flight feather molt on the MoSI banding data sheet, only consider the primaries and secondaries. The prebasic and preformative molt of most north-temperate passerines is completed prior to fall migration; thus, with a few exceptions, it is unlikely that NTMBs will be molting flight feathers during the MoSI season. In contrast, molts of many Neotropical resident landbirds will likely be encountered during MoSI banding. The flight-feather molt field can often be useful for ageing birds. The prebasic molt in adult passerines is normally "complete" -- that is, it includes all body and flight feathers. In contrast, the preformative molt of most species is "partial" -- it includes the body feathers but not the flight feathers, except sometimes the innermost rectrices and the tertials. Be sure to examine all primaries, secondaries, and rectrices. Examine both left and right sides to distinguish symmetric ("S") from adventitious ("A") flight-feather molt.

Acceptable codes for **FLIGHT FEATHER MOLT** include:

N – None. No flight-feather molt.

A – Adventitious or accidental. This type of flight-feather molt is identified by its being asymmetric and occurrence outside of the normal molt period.

S – Symmetric. Normal, essentially symmetric flight-feather molt, indicative of a complete molt in adult birds or an incomplete or complete molt in some young birds. A few species also may exhibit prealternate flight-feather molt.

J – Juvenile growth. Not a molt, strictly speaking. This category refers to growth of juvenile flight feathers in fledgling birds (only to be used for very young birds, just out of the nest, growing their first flight feathers).

NOTE: If a bird is exhibiting flight-feather molt, record as a note the particular group(s) of feathers (primaries, secondaries, and/or rectrices) in which molt is occurring. If possible, record which feathers are new, molting, or growing in each feather tract, using the standard numbering terminology found in Pyle (1997): primaries from innermost (p1) to outermost (p9 or p10), secondaries from outermost (s1) inward to s6 in hummingbirds, s9 in passerines, or higher numbers in other non-passerines, and rectrices from the central pair (r1) to the outer pair (r6 in most species, r5 in hummingbirds and cuckoos). This information can aid in the verification of age data and document NTMB flight feather molt on non-breeding grounds.

FF WEAR – **Flight-feather Wear.** Examine only the outer 4-5 primaries to determine wear.

FLIGHT FEATHER WEAR should be classified according to this scale

0 – None. The feather edges are perfect. A light-colored edge exists all the way around the feathers, including the tips.

1 – Slight. Feather edges are only slightly worn and no actual fraying or nicks have occurred. Often, a light-colored edge exists around the sides of the feathers but not at the tips.

2 – Light. Feathers are definitely worn but with very little fraying and very few actual nicks.

3 – Moderate. Feathers show considerable wear and some very definite fraying. Nicks and chips are obvious along the vanes.

4 – Heavy. Feathers are very heavily worn and frayed. Tips are often worn completely off.

5 – Excessive. Feathers are extremely ragged and torn up, and the shafts are usually exposed well beyond the vanes. All the tips are usually completely worn or broken off.

JUV. PL. – **Extent of Juvenile Body Plumage.** Most fledgling birds wear a juvenile plumage that is distinct, at least in texture, from any other plumage of the species. Juvenile plumage is generally distinguished from adult plumages by loosely-textured ("fluffy") contour feathers that often have streaks or spots not found on corresponding adult feathers. It is important to examine individual feathers in assessing the extent of juvenile plumage. This plumage may be worn from only a few days to several months, depending on species and fledging date, until it is molted into formative plumage ("formative"="first basic" in Pyle 1997) or, in some species, supplemental, plumage (see Pyle 1997 for descriptions and timing of juvenile plumage). The extent of juvenile body plumage on a young bird, therefore, is often a good indicator of how long the individual has been out of its nest. Because young birds of most NTMBs will have completed the preformative molt ("preformative"="first prebasic" in Pyle 1997) by the time they arrive on the non-breeding grounds, this field will likely be useful only for some resident birds during the MoSI season. Flight feathers (primaries, secondaries, and rectrices) are generally not replaced in the preformative molt and should not be considered when assessing the extent of juvenile plumage. In addition, birds of many species retain juvenile wing coverts through their first breeding season – these also should not be considered when assessing juvenile plumage.

The following codes should be used to describe the **EXTENT OF JUVENILE BODY PLUMAGE:**

3 – Full. All contour feathers are juvenile feathers. The bird has not yet begun its preformative (or presupplemental) molt.

2 – More than half. The bird has begun its preformative (or presupplemental) molt, but still has mostly juvenile plumage.

1 – Less than half. The bird has mostly molted into formative (or supplemental) plumage, but some juvenile plumage remains.

0 – None. No juvenile body plumage remains. The individual has already molted into formative (or supplemental) plumage. All adult birds, including SYs, therefore, have "0" juvenile plumage, even if they have some retained juvenile coverts.

In summary, a bird is in full (3) juvenile plumage (JP) from fledging until the onset of the preformative (or presupplemental) molt. During this molt, JP is replaced by formative (or supplemental) plumage. Thus, birds in partial (2 or 1) JP must be in molt. Note, however, that hatching year birds in molt are not necessarily in partial JP. Recently-fledged birds still may be growing their juvenile feathers but should be classed as "3" JP. Similarly, birds in the final stages of the preformative (or presupplemental) molt may have lost all their juvenile feathers but still be growing their formative (or supplemental) feathers; such birds have "0" JP.

MOLT LIMITS AND PLUMAGE – Up to eight fields, which describe individual (or multiple) feather tracts or non-feathered body parts, may be considered for any individual bird. At least one field must be filled in if the bird is aged by molt limits (HOW AGED=L) or plumage (HOW AGED=P). Refer to Pyle (1997) and Froehlich (2003) for additional discussion and examples of the use of molt limits and plumage criteria for ageing landbirds. The eight fields include:

PRI. COVS – Primary coverts
SEC. COVS – Secondary coverts (greater, median, lesser, carpal, and alula coverts and alula)
PRIMARIES – Primaries
SECONDS – Secondaries, not including the tertials.
TERTIALS – Tertials
RECTRICES – Rectrices
BODY – All feather tracts of the head, upperparts and underparts
NON-FEATH – All non-feather parts (bill, mouth, eye, legs, feet). A note is required if this column is used.

The codes entered in these fields reflect the feather generation(s) present within the particular feather tract (or multiple feather tracts in the case of secondary coverts or body plumage). Note that in the material that follows, we use the molt terminology of Howell et al. (2003). In particular, as compared to molt terminology in Pyle (1997), we use "**formative feathers**" instead of "first basic feathers," "**preformative molt**" instead of "first prebasic molt," "**basic feathers**" to mean "adult basic feathers," and "**prebasic molt**" to mean "adult prebasic molt" (See WRP Section above).

Use of any of the following three codes indicates a HY/SY (FPF, FCF, FPA, FCA SPB) bird:

J – Juvenile. Feather tract comprised of all retained juvenile (or a mix of juvenile and alternate) feathers; no formative (= "first basic" in Pyle 1997) feathers are present within the tract. This code should also be used for NON-FEATH if non-feathered body parts show characteristics indicative of a young bird.

L – Molt limit. Molt limit between juvenile and formative feathers exists **within** the tract, regardless of whether alternate feathers are present or not.

F – Formative. Feather tract comprised entirely of formative (or a mix of formative and alternate) feathers; no juvenile feathers are present within the tract.

Use of the following code indicates an AHY/ASY (DCB, DPA, DCA, or DPB) bird:

B – Basic. Feather tract comprised entirely of basic (or a mix of basic and alternate) feathers (basic feathers=adult basic feathers in Pyle 1997). This code should also be used for NON-FEATH if non-feathered body parts show characteristics indicative of an adult bird.

Individuals of some near-passerine species (e.g., woodpeckers) can be aged to SY/TY (SCB or TPB) and ASY/ATY (DCB or DPB; see discussion in Pyle 1997, pp. 39-40) due to incomplete molts, which result in feathers that are retained through the next prebasic (not preformative) molt. Such individuals can have up to three generations of juvenile and basic feathers present within the same feather tract (these species do not acquire alternate feathers). Two codes are to be used to distinguish cases in which juvenile and basic (rather than juvenile and formative) feathers are present from situations in which two generations of basic (not formative) feathers are present:

R – Retained. Both juvenile and basic (rather than juvenile and formative) feathers are present within the feather tract (e.g., see Figs. 25 and 26 in Froehlich 2003). This code would be indicative of a SY/TY (SCB or TPB) bird.

M – Mixed. Multiple generations of basic feathers are present in the tract (e.g., see Fig. 28 in Froehlich 2003). This code would be indicative of an ASY/ATY (DCB or DPB) bird.

The following three codes, although of little use for ageing during the non-breeding season, should be used for feather tracts examined, but not meeting any of the above criteria:

A – Alternate. ALL feathers in the feather tract are of alternate plumage; if **ANY** juvenile, formative, or basic feathers are present, the alternate feathers should be ignored and the code for the feather tract should be based on the other feathers, that is “J”, “L”, “F”, or “B”. This code is only occasionally used (most often for tertials) and provides no useful information for ageing birds.

U – Unknown. This code should be used for any feather tract or non-feathered body part that is examined, but that shows ambiguous characteristics or that cannot be coded with confidence; the feathers in the tract could be juvenile, formative, or basic feathers.

N – Non-juvenile. Feathers in this tract are definitely not juvenile feathers (or a non-feathered body part is not characteristic of a young bird), but whether or not they are formative or basic feathers cannot be determined with confidence. If primary coverts are coded “J” and a molt limit exists between the primary coverts and the secondary coverts, the secondary coverts must be formative feathers and, thus, must be coded “F”, not “N”, even though formative and basic secondary coverts might be indistinguishable from each other.

LEAVE BLANK any field representing a feather tract or non-feathered body part that was not examined or that provides no useful information for ageing the bird.

As an example, consider the identification of a HY/SY (or the appropriate WRP code) bird (i.e., AGE=2 prior to Jan. 1 or AGE=5 after Dec. 31). HY/SY birds are usually identified by the retention of juvenile feathers, which will be evident in some feather tracts but not others (depending on the extent of the preformative molt). Any feather tract for which retained juvenile feathers are evident will have either a "J" or "L" entered in its field, depending on whether molt limits are between or within feather tracts, respectively. If the molt limit is between feather tracts, the tract with juvenile feathers would be coded "J" and the tract with formative feathers would be coded "F." If the molt limit is within the feather tract, the tract would be coded "L." In each of these cases where a molt limit between juvenile and formative feathers can be discerned, the bird should be aged by molt limit (HOW AGED=L). If, however, a molt limit cannot be discerned, but the juvenile feathers present can be distinguished as juvenile (as opposed to basic) feathers by their appearance alone (i.e., color, shape, quality, or wear), the bird would be aged by plumage (HOW AGED=P). Remember, any feather tract or non-feathered body part that was examined, but for which a code could not be determined, should have a "U" entered in its field.

Or consider an AHY/ASY bird (i.e., AGE=1 prior to Jan. 1 or AGE=6 after Dec. 31) after its prebasic molt. Birds of this age are typically distinguished by having undergone complete prebasic molts – adjacent feather tracts show little if any contrast in color or wear. Such birds should have a "B" entered in all fields for which the basic feathers present can be distinguished as basic (as opposed to juvenile) feathers by their appearance alone (i.e., color, shape, quality, or wear), and should be aged by plumage (HOW AGED=P). They should not be aged by molt limits (HOW AGED=L) because there is no molt limit evident. Note that any alternate feathers present provide no information as to whether the individual is a SY or ASY bird.

Finally, it is possible that various feather tracts in an individual bird will show conflicting characteristics (i.e., characteristics that indicate different age classes). When making an age determination for such a bird, give more weight to tracts that are more reliable or have the most obvious reliable features. Although it is not necessary that all tracts in a record agree, you should be confident in your ultimate age designation. A bird with no reliable feather tracts or for which conflicting characteristics make age determination difficult should be aged as unknown (AGE=0) prior to Jan. 1 or AHY (AGE=1) after Dec. 31.

WING – The unflattened wing chord should be determined to the nearest 1 mm using a wing rule (see Pyle 1997 and Ralph et al. 1993 for instructions for measuring wings). Unless there is little or no overlap in wing lengths between sexes (e.g., icterids), DO NOT sex birds by wing length alone in the absence of population-specific wing-chord data. Wing chord and mass are important data collected at MoSI stations because they enable an assessment of body condition.

MASS – Determined **to the nearest 0.1 g** using a portable battery-operated balance.

STATUS – A single, 3-digit code. The most-frequent codes are:

- 300 - normal wild bird captured, banded, and released
- 301 - normal wild bird captured, banded and color-banded, and released
- 500 - injured banded bird
- 501 - injured banded and color-banded bird.
- 000 - not banded, or died prior to release.

Any status other than 300-level codes requires a disposition note (see DISP below).

DATE (DAY/MO) – Day/month. Record the date of capture as day and month, all in numbers. The year is entered once on the top of the form. Record months and days as two-digit numbers (e.g., June is written "06").

CAPTURE TIME – Using the 24-hour clock, record, to the nearest 10 minutes, the starting time of the net run on which the bird was extracted. Thus, all birds extracted (or escaping) on a given net run will have the same capture time entered. Do not enter the time at which the bird was extracted, processed, or released. Always enter three digits. For example, 7:30 a.m. or 07:30 would be entered as 073, and 2:40 p.m. or 14:40 would be entered as "144".

STATION –The four-character code for the MoSI station, determined during station registration.

NET – A 2-digit, numeric code to indicate the net site at which the bird was captured (e.g., 06). It is important that net codes not include alpha characters or be more than two characters long.

DISP – Disposition. A code indicating the final disposition of an injured or dead bird. A bird is considered injured if its survival probability is compromised or, for healed injuries, could have previously been compromised. A minor flesh wound or loss of a few feathers is not worthy of note. Injured or dead birds should have a status code of 500 or 000 respectively and a note that describes the nature of the injury or cause of death.

We recognize nine categories for injured birds and two for dead birds:

Injured birds

M – Malformed (e.g., crossed mandibles)
O – Old (healed) injury
I – Ill or diseased
S – Stress or shock
E – Eye injury
T – Tongue injury
W – Wing injury (often, unable to fly)
B – Body injury
L – Leg injury

Dead birds

P – Predator-caused mortality
D – Death due to a cause other than predation

NOTE NUMBER – Enter a number (starting with "1" on each page) if additional information is recorded and record this information with the corresponding note number in the NOTE NO. field on the back of the banding-data sheet. Occasionally notes associated with a record indicate that the species determination for a recapture or an unbanded bird was uncertain. **Mark these records by recording "QS" in the NOTE NUMBER field.**

FTHR. PULL – Feather Pull. Enter a code from the list below indicating which feathers were pulled during this capture event. Only record this information when the feathers are actually pulled, not on a recaptured bird that has previously had feathers pulled. If no feathers were pulled, leave the field blank.

O – Outer two rectrices were pulled (i.e., rectrix 6 from both the left and right side of the tail). Previously, this was indicated by FTHR. PULL=P.

I – An inner and an outer rectrix were pulled (i.e., rectrix 1 from one side and rectrix 6 from the other side were pulled).

COLOR BANDS – If you are interested in developing a color band system and program of monitoring, please contact IBP for assistance in setting up research objectives and methods.

NOTE NO. – Corresponds to the NOTE NUMBER field on the front of the banding sheet and is used to index all additional notes taken for each record.

NOTE – Record notes on the back of the banding-data sheet. These include characterizations of examined feather tracts in adult birds (see AHY/SY/ASY/TY/ATY above). Other examples of notes include measurements of difficult-to-identify species such as *Empidonax* flycatchers; documentation of rarities or extralimital species; suspected age or sex determinations of birds given age code "0" or sex code "U"; details of any "O" (other) code for HOW AGED or HOW SEXED; and explanations for injured, dead, and unbanded birds. Please be liberal in your note-taking, especially to indicate which, if any, flight feathers are missing, erupting, or in sheath.

7. Feather Collection

In order to help link breeding and non-breeding migratory bird populations, we encourage MoSI station operators to collect feathers from migratory birds captured at their stations. These feathers will be archived and analyzed as part of the Bird Genoscape Project (www.birdgenoscape.org). There is a short film about this project, and the MoSI program's involvement in it at https://www.youtube.com/watch?v=_p43ksRgIlk.

7.1 Feather Collection Protocol

Feathers can be collected from any species, bearing in mind that permits are required for U.S. banders working with endangered species. The BGP maintains a list of priority species, which change from time to time. Current priority species can be found at https://www.birdgenoscape.org/highlighted-species/.

For up to 30 individuals of priority species per location, one inner and one outer rectrix should be pulled, one from each side of the tail. It is very important not to touch the tip of the rachis of pulled feathers as this is where the epithelial cells for DNA extraction will be taken. Pulled feathers should be placed in an envelope (one envelope per sample, available from IBP or the BGP) and sealed. The following information should be clearly recorded on the outside of each envelope:

- Species
- Band Number
- Date
- Locality (station name, state or province, country)
- Age, sex, and reproductive condition.

At the end of each MoSI season, contact IBP or the BGP for information on where to send feathers. **The BGP can assist with obtaining permits, and will pay for any shipping costs.**

8. Summary of Mist-netting Results

This summary allows us to ascertain whether all capture records have been submitted for each station. It also allows us to check whether the date and station code were correctly recorded for each capture. This form can be obtained from regional MoSI coordinators or downloaded at www.birdpop.org/MoSI/MoSI.htm.

8.1 Completing the Summary of Mist-Netting Results Form

Complete this form at the end of each banding day using your raw banding-data sheets.

Location: Your four-character location code.
Station: Your four-character station code.
Year: Current non-breeding season (i.e., 2009-10).
Intended Pulse: The pulse number for which the day's effort was intended.
Date: The month and day of the date operated.
New: Number of new individuals banded. Dead birds are recorded as *unbanded*.
Unbanded: Number of birds captured but not banded, including birds that died before release.
Recaps: Number of Recaptures, including previously-banded birds that escape or are released before the band number is read, and birds with replaced or added bands.
Total: Tally the number of new, unbanded, and recaptured birds for each day of operation. At the end of the season, record the totals of these three categories at the bottom of the form.

9. Data Submission

All MoSI data should be submitted as e-mail attachments to the U.S. MoSI Program Coordinator, Steven Albert (salbert@birdpop.org).

Data submitted annually should include the following forms:

- Completed MoSI Banding Sheets
- Completed MoSI Unbanded Sheets
- Completed MoSI Recaptures Sheets
- Completed Summary of Mist-Netting Effort for each station
- Completed Summary of Mist-Netting Results for each station

Data should be submitted as a Microsoft Excel spreadsheet. Be sure to enter data for a single field of the banding sheet into a single spreadsheet cell (**e.g., band number should be recorded in a single cell, not spread out over nine cells**). Include *only the fields included on the raw data sheets*; these fields should *follow the same order as they appear on the banding-data sheets.*

Templates for all data sheets are available at https://birdpop.org/pages/mosiDataForms.php.

Cooperators should submit the entire season's data as soon as possible after completion of the season's work.

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Appendix A. Ethics During Field Work

The MoSI program is operated for the benefit of its cooperators and the care and protection of biodiversity, which is why we must remember to take into account the following standards, which have been adapted from the bird bander's code of ethics:

1. The welfare of birds is the priority of all collaborators. Long waits between net checks should be avoided (average time is 40 min). Nets should not be exposed to the sun, ants and other pests, or anything that negatively affects the safety of birds.

2. Learn to identify signs of stress or fatigue in a bird and release it as soon as necessary into a shady place.

3. Avoid prolonged bird-in-hand times for photography or other activities not directly related to banding.

4. Graciously give and receive professional critique of the performance of other banders, and that of your own.

5. Constant monitoring of volunteers with lack of experience is essential.

6. Work in constant communication with other banding stations to promote learning.

7. Stay informed with literature or information on bird banding and share this information with other cooperators and your staff.

8. Respect private property and the rules of behavior at the sites where you are banding.

9. Safeguard and maintain banding equipment in a safe place.

10. Make sure your data is accurate, complete, and legible.