Chapter 2

Coordination and Framework of a National Integrated Pest Management Program for *Lymantria dispar*

Tom W. Coleman, Christopher J. Foelker, and H. Mannin Dodd

Abstract

The National Slow the Spread (STS) Program represents the largest strategy to limit the impacts of the exotic spongy moth, *Lymantria dispar* L. (Lepidoptera: Erebidae, formerly known as the "gypsy moth"), in the United States. The STS Foundation, a non-profit organization, state and federal agencies, and university partners work collaboratively in three committees (operations, regulatory, and technical) to reduce the rate of spread of *L. dispar.* Since 2000, state agencies and the U.S. Department of Agriculture (USDA) Forest Service annually plan and implement trap and treatment activities, coordinating work through the non-profit foundation and gaining approval from the board of directors. Trap and treatment activities are planned and archived in a centralized database. From 2000 to 2020, mean annual funding directed to carry out trapping was $4.59 million, and $5.47 million was used for treatments.

Keywords: defoliator, geographical information system, gypsy moth, integrated pest management, invasive insect, spongy moth

Authors

Tom W. Coleman is an entomologist and the Slow the Spread Program Manager, USDA Forest Service, Forest Health Protection, 200 W.T. Weaver, Asheville, NC 28804, 828-257-4399, tom.coleman@usda.gov.

Christopher J. Foelker is a Forest Pest Survey Unit Supervisor, Wisconsin Department of Agriculture, Trade and Consumer Protection, Madison, WI.

H. Mannin Dodd is a research associate in the Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, VA.

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Citation

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INTRODUCTION

The National Slow the Spread (STS) Program represents one of the longest running and most geographically expansive integrated pest management programs in the world (Sharov et al. 2002, Tobin and Blackburn 2007). The program's goal is to slow the rate of spread of spongy moth, *Lymantria dispar* L. (Lepidoptera: Erebidae, formerly known as the "gypsy moth"), by greater than 60 percent from its historical rate of spread (19.6 km/yr, an average of historical spread rates) in the United States (Liebhold et al. 1992). The Slow the Spread Foundation, a non-profit foundation, together with 12 states, two federal agencies, and two universities, have contributed to the success of the program since its inception in 2000. These groups work collaboratively throughout the year under the structure of three committees to successfully meet the goals of the program. In addition, the Slow the Spread Information Systems Group (STS-ISG) manages a centralized database and develops and maintains planning tools, archives project information, and manages the Slow the Spread decision algorithm (STS DA). A key component of the program, the STS DA defines program boundaries, objectively identifies newly established isolated *L. dispar* populations in the transition area, recommends management actions, and evaluates treatment success and moth spread (Tobin and Sharov 2007, Tobin et al. 2007a). This paper describes the framework for the STS Program, the roles and timing of work in the three support committees, and the funding trends for the national program, with the intention that this information can be used as a guide for future integrated pest-management programs that incorporate multiple agencies and span large landscapes.

PROGRAM PARTICIPANTS AND STRUCTURE

The Slow the Spread Pilot Project (1992–1999) began with four state partners: Michigan (MI), North Carolina (NC), Virginia (VA), and West Virginia (WV). The pilot transitioned into the national program in 2000 with the addition of Illinois (IL), Indiana (IN), Ohio (OH), and Wisconsin (WI) (Fig. 1) (McManus 2007). Kentucky (KY) joined STS in 2001, followed by Minnesota (MN), Iowa (IA), and Tennessee (TN) as the program boundaries moved into these states (Leonard 2007). In 2011 Michigan exited from the program because the entire state was generally infested, and trapping for the evaluation zone moved out of the state. No new states have joined the program since 2013; however, South Carolina and Missouri could be the next states to join STS because of their proximity to the program boundaries and *L. dispar* spread.

The program commonly separates the partnering states into three regions (southern, central, and northern) based on their similar land use and host composition. These regions also share similarities in spongy moth phenology and in how STS is implemented. The southern region is comprised of Kentucky, North Carolina, Tennessee, Virginia, and West Virginia; the central region is comprised of Illinois, Indiana, and Ohio; and the northern region is comprised of Iowa, Minnesota, and Wisconsin (Fig. 1). Across the three regions, Virginia, Ohio, and Wisconsin typically contain the majority of potential problem areas (PPAs), that is, isolated, low-density populations in the transition area (Tobin and Sharov 2007) and treatment blocks in the program, in part because the transition area bisects large areas in these states, where greater rates of spread can occur and because treatments tend to be aggressively implemented there. Although the STS Program is implemented uniformly across the three regions, variations in land cover, forest composition, and Allee

effects (i.e., a decrease in per-capita fitness caused by a decrease in population size) cause some regions to treat populations more aggressively in the transition area. As such, the STS DA commonly does not recommend treatments for lower density populations (ca. five moths/trap) in the northern region; however local expertise encourages a more aggressive treatment approach than recommended by the STS DA, and catch or colony persistence indicates weaker Allee effects along the northern leading edge[1] (Tobin et al. 2007b, Whitmire and Tobin 2006).

The STS Foundation (comprised of a board of directors and an administrative officer) and three STS committees (operations, regulatory and technical) help coordinate the work of the program among state and federal agencies. The three committees work in close coordination with each other, and state and federal staff often hold multiple roles in each committee. The board of directors oversees the work of the operations and regulatory committees and coordinates their work through the STS Foundation.

OPERATIONS COMMITTEE

The operations committee represents the core decision-making in the STS Program; these decisions are planned and archived using the centralized STS database, which also facilitates summarization of trapping and treatment activities. The STS Foundation and federal and state partners comprise the operations committee and work closely together to meet the program's objectives.

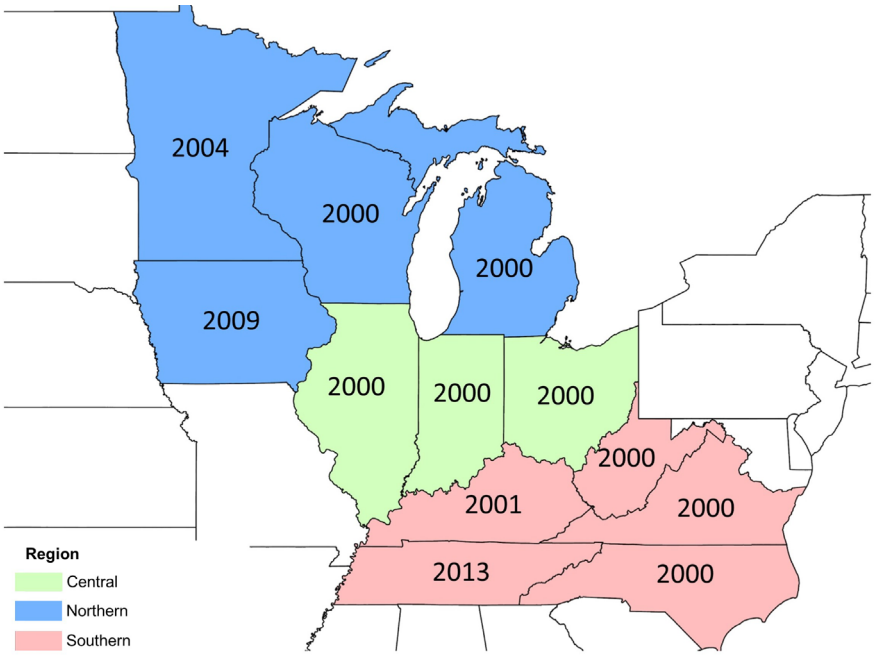

Figure 1.—State partners active from 2000 to 2020 in the National Slow the Spread Program. Years represent when each state joined the program. Michigan left the national program in 2011.

[1] See spread rates in Wisconsin, zones 2 and 3, in Coleman et al. 2023, this report page 45.

Slow the Spread Foundation

The framework for the STS Foundation, a non-profit organization, was structured similarly to the USDA Boll Weevil Eradication Program in the southern United States to address the cotton boll weevil, *Anthonomus grandis* Boheman (Coleoptera: Curculionidae). The primary function of the STS Foundation is to serve as the highest level of unified management across the member states, which solidifies ownership and accountability, promotes transparent planning and financial transactions, and standardizes operational materials and methods. The foundation has been staffed by one administrative officer since 2000, and the offices of president, vice-president/treasurer, and secretary have been filled by member states. The USDA Forest Service annually awards a grant to the STS Foundation early in the calendar year to support the trapping and treatment programs in each state, which the foundation distributes as subawards. Federal funding accounts for the majority of the program funding, and these funds are matched by state funding (Table 1). The administrative officer works closely with the STS program manager and the vice-president/treasurer for the STS board of directors to implement the trapping and treatment programs. The administrative officer awards subgrants to individual states for trapping and treatment work, submits grant and reimbursement requests, and maintains program files. Some participating states are unable to hire or contract trappers, in which case the STS Foundation directly contracts trappers and disperses payments after work is verified by state program managers. The foundation also manages grants for research and regulatory work, purchases the active ingredient for the mating disruption applications, supports spray calibration meetings, and reimburses travel for state cooperators. An outside accounting firm annually conducts an audit of the foundation's funds.

The STS board of directors is comprised of one person from each participating state, commonly the state's plant regulatory official or the state's STS program manager. Some states do not have a voting representative on the board due to state restrictions or limited involvement with the program. The president, vice-president/treasurer, and secretary are voted into office at the annual meeting of the board of directors (Table 1). At the annual meeting, the previous year's accomplishment report, the previous year's quality assurance-quality control (QA-QC) report, and the current year's plan of work are reviewed. The annual external audit report of the STS Foundation's expenses is also reviewed, along with other pertinent program issues from the USDA Forest Service (USDA FS), the USDA Animal and Plant Health Inspection Service (USDA APHIS), and the participating states. Conference calls are held monthly with the board of directors to inform members of recent program activities, budget allocations, and grant reimbursements, and to discuss new business topics.

State and federal STS collaborators plan and attend three meetings throughout the year to discuss program planning, annual accomplishments, aviation topics, and advancements in *L. dispar* research. These include a winter operations meeting, a summer operations meeting, and the Annual *Lymantria* Review Conference. The winter meeting reviews the previous year's accomplishment report, the current year's plan of work, and state and federal budgets. Coordination with the STS-ISG, advancements in trapping hardware and software, and trapping protocols are also planned and discussed at the meeting. The summer meeting provides an opportunity to review end-of-season accomplishments for all *L. dispar* treatments (i.e., states with suppression, eradication, and/or STS treatments); to discuss aviation issues, safety, and training; and to begin planning for next year's efforts. This meeting is planned by the National *Lymantria* Management Board (NLMB),

which also plans the Annual *Lymantria* Review. The Annual *Lymantria* Review provides updates on recent research associated with *L. dispar* and other forest insect pests and an opportunity for the NLMB to meet and discuss recent activities.

Federal Cooperators and Roles

The USDA Forest Service has provided a National Program Manager, several entomologists, and technicians to support the annual work. These positions have been commonly stationed throughout the STS Program area (e.g., Asheville, NC; Morgantown, WV; and St. Paul, MN) to support participating states. The STS program manager coordinates annual trapping and treatment plans across all the states to meet current fiscal year funding levels. As the coordinator of this effort, the program manager procures annual trapping supplies from November to December from the USDA Animal and Plant Health Inspection Service through an interagency agreement (USDA APHIS places consolidated orders supplying both the STS Program and the *L. dispar* detection program in uninfested states) and then coordinates the delivery of traps, lures, and Dimethyl, 2, 3-dichlorovinyl phosphate insecticide strips in March to the states. USDA Forest Service funding supports the STS Foundation, the Information Services Group (STS-ISG) at Virginia Polytechnic Institute and State University (VT) and Michigan State University (MSU), and *L. dispar* technology development to improve trapping and mating disruption applications and increase our understanding of population spread (Onufrieva 2023, this report). The STS program manager plans and monitors the funding for each of these grants. USDA Forest Service entomologists and technicians have assisted the preparation and review of state environmental assessments for treatments in STS and routed these documents for approval. These positions also support mating disruption treatment planning, contracting, and applications and QA-QC for trapping. *Lymantria dispar* defoliation and treatment acres are tracked annually by the USDA Forest Service for suppression, eradication, and slow the spread projects (USDA FS 2021).

During the fall planning meetings, the program manager and state personnel review trap catches and PPAs from late September to early December to plan program boundaries, delimit-trapping grids, and treatment blocks for the upcoming year. These management decisions are guided both by the recommendations of the STS DA and by local expertise in each state (Table 1, Fig. 2). In the early years of the program, the STS program manager, database personnel, and support staff traveled to each state to hold annual fall planning meetings (Leonard 2007). These annual meetings became an integral part of the program planning and provided face-to-face interaction with state cooperators to plan the next year of work and were often referred to as "roadshow" meetings. As technology improved, these planning meetings were conducted by conference calls and in online meeting platforms.

Treatment blocks are commonly adjusted (i.e., treatment type changed, and/or blocks are reduced in size, deleted, or changed to a delimit-trapping grid) in several iterations to balance budget limitations prior to the STS board of directors meeting in mid-February. At that point, treatment blocks are finalized, and planning work transitions into a preparatory phase to implement the treatments. The STS program manager oversees the mating disruption applications under a USDA Forest Service contract. The applications are provided as a service to state treatment programs. The Forest Service contract was initiated in the early years of the program to develop and refine the application technology and to enhance coordination and standardization of the applications. It has been maintained as

a federal contract to reduce the cost of applications by offering more work to contractors under a single contract (Appendix). The mating disruption contract must be awarded or renewed early in the calendar year (February to March) to meet Forest Service requirements (e.g., aircraft and pilot inspections/carding, aviation safety planning, and pre-operational planning meetings). Mating disruption applications commonly span from the first week of June to mid-July, with applications beginning along either the Atlantic Coastal Plain or piedmont of Virginia and North Carolina and ending in the northern regions of either Wisconsin or Minnesota near Lake Superior (Table 1).

Table 1.—Annual timeline of activities conducted by the partners, including state program managers and support staff (States), the Information Systems Group (STS-ISG), the STS program manager (PM), USDA Animal and Plant Health Inspection Service (USDA APHIS), USDA Forest Service (USDA FS), and *L. dispar* (Ld) private contractors/cooperators/researchers of the National Slow the Spread Program.

Activity	Timeline	Participants
Current season trap data finalized in STS database	Aug.–Nov.	States, STS-ISG
Review of trap catch data and pre-planning of next season's trapping and treatment work	Sept.–Dec.	States, PM
"Roadshow" planning meetings to discuss program boundaries, treatment blocks, delimit blocks, current issues	Oct.–Dec.	States, PM, STS-ISG
Annual *Lymantria* Review Conference	Early Nov.	States, USDA FS, Ld contractors/ cooperators/researchers
Preliminary budget planning	Dec.–Jan.	States, PM
Winter Operations Committee meeting to review previous year's accomplishment report and discuss current season's actions and budgets	Mid-to-late Jan.	States, PM, STS-ISG
Technical Committee meeting to discuss knowledge gaps, review previous year's work, discuss and vote on new projects	Mid-to-late Jan.	States, PM, Ld researchers, USDA FS
Public scoping for treatment applications	Dec.–Apr.	States, USDA FS
STS Board of Directors meeting to finalize previous year's accomplishment report and current year's program of work, approve QA-QC report, review external audit	Mid-Feb.	Board of Directors, PM, USDA APHIS
Annual grants and treatment contracts awarded	Feb.–Mar.	States, PM, STS Foundation, STS-ISG, Ld researchers, USDA FS, USDA APHIS
Trap and treatment grants and research awarded to state programs	Feb.–Mar.	STS Foundation, States, Ld researchers
Preparation/review/approval of environmental analyses for treatment applications	Feb.–May	States, USDA FS
Larvicide applications	Apr.–May	States, Ld contractors
Trap placement, monitoring, quality assurance/quality control	Mar.–Oct.	States, Ld contractors
Mating disruption applications	June–mid-July	States, PM, USDA FS, Ld contractors
Summer Operations Committee meeting to discuss end of the year accomplishments, aviation issues, begin planning for next season	Early Aug.	States, USDA FS, Ld contractors

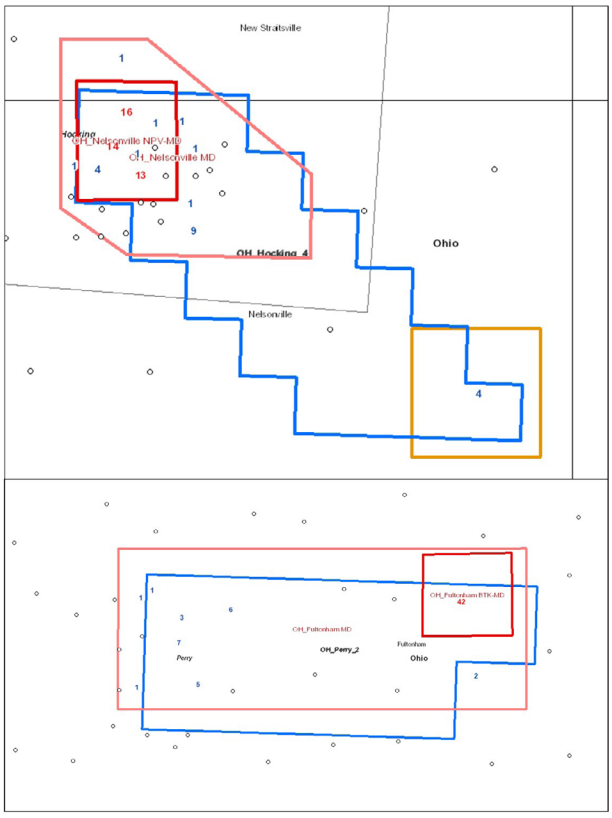

Figure 2.—Examples of delimit-trapping grids (yellow polygon) and larvicide (red polygons) and mating disruption (pink polygons) treatment blocks planned around *Lymantria dispar* trap catches (numbers and white circles represent zero trap catches) and potential problem areas (blue polygons) in the centralized database. The National Slow the Spread Program decision algorithm identifies isolated, low-density populations in the transition area as potential problem areas.

State Cooperators and Roles

In 2020, the STS Program partnered with 11 state cooperators, including several departments of agriculture (IA, MN, NC, OH, VA, WV, and WI), two departments of natural resources (IN and IA), a state entomology office at the University of Kentucky (Lexington, KY), and a division of forestry (TN) (Fig. 1). Most state cooperators in STS are, or have been, representatives from department of agriculture offices due to their regulatory authority. The Michigan Department of Agriculture was a cooperator during the pilot project, but their participation was terminated early in the operational program because the *L. dispar* transition area moved out of their state. Even so, Michigan continues to assist the program by annually certifying the calibration of spray booms for aerial larvicide applications, and a limited amount of *L. dispar* trapping still occurs in the southern part of the state to assist population growth and spread models that are monitored by the STS-ISG.

State program managers direct the STS programs within their respective states with input and assistance from the national program manager and have two primary objectives: (1) to coordinate and implement state trapping programs and (2) to contract and implement larvicide pesticide applications for higher density *L. dispar* populations (>60 moths/trap or presence of immature life stages) and assist with mating disruption applications. Planning for trapping and treatment programs begins as early as October, soon after final trap catches are reviewed and finalized in the centralized STS database (Table 1). Following the recommendation of the STS DA and local expertise, each state delineates draft treatment and delimit-trapping plans in the database prior to a planning meeting with the national program manager (Fig. 2). Following completion of annual planning at the winter operations meeting in January, treatment blocks are finalized, and from December to April, state personnel solicit public comments for environmental assessments (Table 1). Public scoping for environmental assessments includes mailing landowners in and adjacent to treatment blocks (<1.6 km or less); press releases; local, county, state, and federal government mailings; public meetings; online and social media content; and discussions with local government officials. States submit environmental assessments from March to April to the USDA Forest Service for review and approval to satisfy National Environmental Policy Act of 1969 requirements for federal funding. State programs and aerial applicators also coordinate treatment blocks with local federal safety district offices of the Federal Aviation Administration for flight plans in congested areas.

To implement trapping and treatment activities, state programs typically receive federal funding from the STS Foundation early in the calendar year (February through April). Federal funding can support program staff, establish contracts for pesticide applications, and hire seasonal trappers (Table 1). State programs define trapping territories (i.e., bid units) from February to March in the centralized STS database, and seasonal trappers are hired and trained soon after this period. Trappers receive electronic trapping hardware (e.g., GPS, phones, and computer tablets) and trapping supplies (e.g., delta and milk carton traps, staplers, gloves, wire, lures, and pest strips) for the current field season and are required to upload trapping information to the centralized database regularly. The STS Program commonly employs approximately 175 seasonal trappers per year. Teachers, college students, retirees, outdoor enthusiasts, and state staff are commonly employed as trappers, and many return year after year. Trap placement begins in the southern region of the program by late March and can extend into July in the northern region of the program. Traps are retrieved from August to October across the range of the program. State program managers and lead trappers coordinate workloads, train new trappers, and conduct QA-QC of traps. State programs conduct annual QA-QC inspections of their trapping programs (at least 10 percent) in a year. Quality assurance-quality control for trap monitoring annually has met program expectations (Coleman et al. 2023, this report page 45), providing a constant and reliable data stream to plan and evaluate treatment programs (Table 2). The STS database provides an annual QA-QC report that is reviewed by the board of directors at their annual meeting.

State program managers solicit larvicide treatment contracts from January to April for the upcoming treatment season. State program managers possess operational control for all treatments blocks in the state and follow accepted guidelines for applications (Appendix). Larvicide contracts are awarded or renewed as early as March to ensure applications occur during the appropriate treatment application window (i.e., biowindow). Timing of work objectives varies across the program, with most work generally occurring first in the southern

region, second in the central region, and last in the northern region as *L. dispar* phenology progresses over a season (Table 1). Work in higher elevations of North Carolina, Virginia, and Tennessee are typically delayed from other regions in the state to better align with *L. dispar* phenology.

REGULATORY COMMITTEE

The regulatory committee regulates, inspects, and educates public and private groups about *L. dispar* for the STS Program. The USDA Animal and Plant Health Inspection Service (APHIS) has funded regulatory activities in several STS states via the STS Foundation to increase industry and public awareness; to reduce the human-facilitated spread of *L. dispar;* to identify, monitor, and establish compliance agreements with high-risk facilities (e.g., lumber yards, nurseries, holiday tree lots); and to document and evaluate regulatory activities. This work represents the main focus of the regulatory committee activities in the STS Program. Since 2017, regulatory work has been focused in Illinois, Minnesota, Virginia, West Virginia, and Wisconsin. The committee is co-chaired by USDA APHIS and a state partner (Leonard 2007).

TECHNICAL COMMITTEE

The STS technical committee is made up of university, federal, and state personnel with experience in *L. dispar* biology and management, population ecology, biological invasions, and invasive species spread. The technical committee analyzes emerging issues, provides technical and expert information, and recommends changes to the program (e.g., changes to the STS decision algorithm) as well as annual technology development projects to the entire STS Program. The technical committee has been chaired by a USDA Forest Service scientist and a university scientist (Leonard 2007). Examples of projects supported by STS can be found in Onufrieva (2023, this report). The committee holds an annual technical meeting, usually in coordination with the operations' committee winter meeting.

CENTRALIZED DATABASE

A centralized STS database has been managed by STS-ISG, the information services group comprised of geospatial developers and information technology (IT) specialists, since the conception of the program in the Departments of Entomology at VT and MSU (Ziegler and Roberts 2007). Aspects of the database were initially developed during the Maryland Integrated Pest Management Project (MD-IPM), Appalachian Integrated Pest Management Project (AIPM), and STS Pilot Project, which were also managed by VT (MD-IPM and AIPM) and MSU (AIPM only). The STS-ISG develops and implements the STS Program's geospatial strategy and provides the foundation for all information management and product distribution. The STS-ISG provides development and operations support in the following functional areas: information technology infrastructure and data management, analytics and decision support, design and planning, field mobility and monitoring, and information sharing and collaboration.

Information Technology Infrastructure and Data Management

All STS trapping, treatment, analysis, and planning data are managed in ESRI (Redlands, CA) ArcGIS server geodatabases integrated with Oracle relational databases. These datasets of current and historical program data are shared through the STS ArcGIS Online (AGOL) organization (ESRI), which enhances cooperator access for sharing and editing STS data in a web environment. Over time, the information system resources required to support the STS Program's operations have increased, migrating from a single FTP server to a robust array of virtual servers and web hosts. This server array provides STS developers with development, staging, and production environments to allow for continuous integration and easier deployment of new features and applications. System administrators have created redundant backup and replication processes for the virtual servers and implemented strong security protocols and firewall rules to protect the server array. Program data continue to be collected, organized, and maintained in an Oracle relational database with the spatial components managed by ESRI's ArcGIS Enterprise software suite. Database managers maintain current versions of the database and geographic information system (GIS) software to allow developers access to the latest tools and environments. As commercial, off-the-shelf web GIS and mobile data collection applications have matured, STS-ISG has migrated most mapping and data visualization products to an ArcGIS Online system and developed a new trapping data collection workflow using the ArcGIS Collector mobile application. To take advantage of the centralized environment provided by ArcGIS Online, STS-ISG has migrated the STS website into two integrated ArcGIS Hub initiatives: one publicly available STS Program Hub and one password-protected STS Operations Hub (VT 2021).

Field Mobility and Monitoring

Trap location and catch information are the core of all STS data, providing input for analysis and mapping the spread of *L. dispar.* To facilitate trapping data collection in the field and provide QA-QC processes, the STS-ISG began developing a custom mobile software application (Trapper Gadget, G1) in 2002. Trapping software and hardware have been updated throughout the life of the STS Program to address advancements in technology and improve the user interface to reduce errors (Table 2). After trapping areas are finalized in mid-February (Table 1), the STS-ISG creates trap sites (nodes) and target circles (areas around each node where traps may be placed) for the coming season (Roberts and Ziegler 2007), and state personnel begin designing bid units (trapper territories) to apportion the trap placement and monitoring work within their state. Since the beginning of the national program, GIS software has been used to aid in the design and planning process. Initially paper maps were created and mailed to state cooperators ahead of in-person "roadshow" planning meetings. Next, STS-ISG developed custom GIS tools to facilitate planning data entry and validation, and state personnel used GIS software on their own computers to create trapping and treatment plans. The current version of the STS planning editor is a web-based GIS application that allows state and federal cooperators to plan activities without needing any additional software on their computers (Table 3). The STS-ISG has developed and maintained additional editing software (e.g., STS Bid Unit, Field Data Collector, Treatment Application Planning, and Regulatory Sites) to plan and implement the STS Program (Table 3).

Table 2.—Trapping software and hardware developed and updated by the Slow the Spread-Information Systems Group (STS-ISG) to facilitate the data collection of tens of thousands of traps monitored by the National Slow the Spread Program

Trapping Software	Year	Hardware and language
G1	2002	Pocket personal computer personal digital assistant (PDA), Visual C++
G2	2009	PDA, Javascript/HTML/CSS
G3	2014	Mobile devices (phones, tablets), C#.NET
External mapping support	2016	ArcGIS Collector (ESRI, Redlands, CA)
G4	2020	Mobile devices, collector for ArcGIS, supporting processes in C# and Python (piloted in 2019 and expanded to four states in 2020, and implemented program-wide in 2021)

Table 3.—Software developed and maintained by the Slow the Spread-Information Systems Group (STS-ISG) to facilitate the planning and implementation of the National Slow the Spread Program (STS)

Software	Purpose
STS Planning	Allows cooperators to create and update trapping and treatment grids and provides summary reports from a web-based GIS application
STS Bid Unit	Provides tools and reports to help design trapper territories and manage trapping work
Field Data Collector (mobile data-collection application)	Allows field personnel to record *L. dispar* life stage locations, local vertical hazards, and restricted areas associated with planned treatments
Treatment Application Planning (collection of applications, including military training routes and aeronautical charts)	Supports treatment program and aims to improve application safety
Regulatory Sites	Allows cooperators to manage their USDA Animal and Plant Health Inspection Service (APHIS) regulatory trap sites to be incorporated into the STS trapping workflow

Analytics and Decision Support

The STS-ISG maintains the STS decision algorithm (STS DA), which analyzes trap catch data and provides management recommendations, representing the foundation of the Program, (Tobin and Sharov 2007). The results of the STS DA analysis are used to plan the next season of work and are available as GIS layers in STS planning applications. Since 2007, the STS DA has been updated numerous times to address PPA updates; to integrate with the STS database and GIS layers; to re-write the computer language from ASP.NET to C#; to change STS regions from four to three; to develop a one region kriged (spatially

interpolated) trap catch layer; to expand phenology analyses; and to develop a long-term spread rate and trap-based treatment evaluations.

PROGRAM FUNDING

One of the earliest challenges of the STS Program was the ability to expand the STS Pilot Project area to a larger, multi-state area. As a result, trapping and treatment programs increased during the latter years of the pilot program and at the beginning of STS to demonstrate that the program could function at a national scale. The pilot project demonstrated the feasibility of a national program, and a cost-benefit analysis helped support the national program (Leuschner et al. 1996).

In 2000, the National STS Program was launched and allocated $8.3 million in federal dollars from the USDA Forest Service. Funding was increased to $10 million in the first several years of the program and was earmarked by the U.S. Congress (Fig. 3). Total STS funding from 2000 to 2020 was $238,171,952 with a mean (±SE) annual total funding of $11,341,521 (±311,441). Total USDA Forest Service contributions were $182,606,674 during this time, and state contributions totaled $52,366,072. From 2000 to 2020, the mean annual federal funding allocated to STS was $8,695,556 (±267,349), whereas the mean annual state funding during this same period was $2,493,622 (±169,806). Peak federal funding occurred in 2004 at $11 million (Fig. 3). Since 2011, federal funding has been in a general decline, with the lowest annual funding ($7 million) allocated in 2018. Mean annual monitoring costs from 2000 to 2020 were approximately $4.59 (±0.11) million, whereas mean annual treatment costs were $5.47 (±0.29) million. Mean annual technical development and mean annual indirect costs were $0.22 (±0.01) and $0.94 (±0.04) million, respectively. Regulatory committee work has been supported annually by USDA Animal and Plant Health Inspection Service funds and had a mean annual funding level of $208,300 (±25,651) (data obtained from 2000–2005 and 2017–2020).

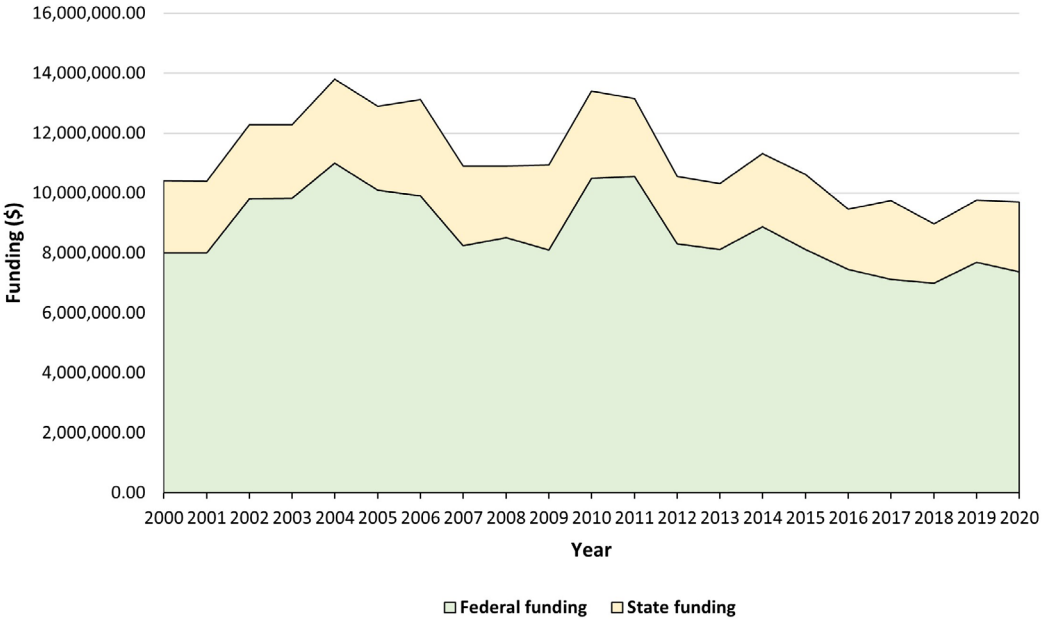

Figure 3.—Federal and state funding from 2000 to 2020 utilized for the National Slow the Spread Program.

The STS Program strives to balance federal funding between trapping and treatment programs, targeting an approximate 50:50 allocation. Generally, the program has succeeded in balancing this work (Fig. 4). For the comprehensive budget data available (2005–2020), trapping programs accounted for 44 percent (±0.84) of the annual program budget, database management accounted for 9 percent (±0.38), treatments accounted for 45percent (±1.19), and technical work accounted for 2 percent (±0.17) of the annual federal funding (Fig. 4). However, recent declines in federal funding and increased base program costs have shifted the program closer to a 60:40 allocation between trapping and treatment programs. In recent years, approximately $4 million has been required to fund the trapping program (i.e., state trapping programs and the centralized database), which is the foundation for all the program's work.

Delays in awarding annual federal funds to the STS Foundation continue to cause significant hurdles for the program, since *L. dispar* is an early-season defoliator. Annual budget planning numbers are needed by December, or as early as possible, to facilitate budget and environmental planning, initiate new grants, solicit contracts for trapping and treatment activities, and hire personnel. The general decline in federal funding primarily reduces the number and size of treatment blocks. Since 2018, 24,000 to 40,000 treatment hectares have been cut from the STS Program due to budget limitations. However, the program has still been able to meet its main objectives of reducing the rate of spread of *L. dispar* by greater than 60 percent (Coleman et al. 2023, this report page 45, VT 2021), thereby delaying the negative ecological and economic impacts associated with *L. dispar* outbreaks (Coleman 2023, this report).

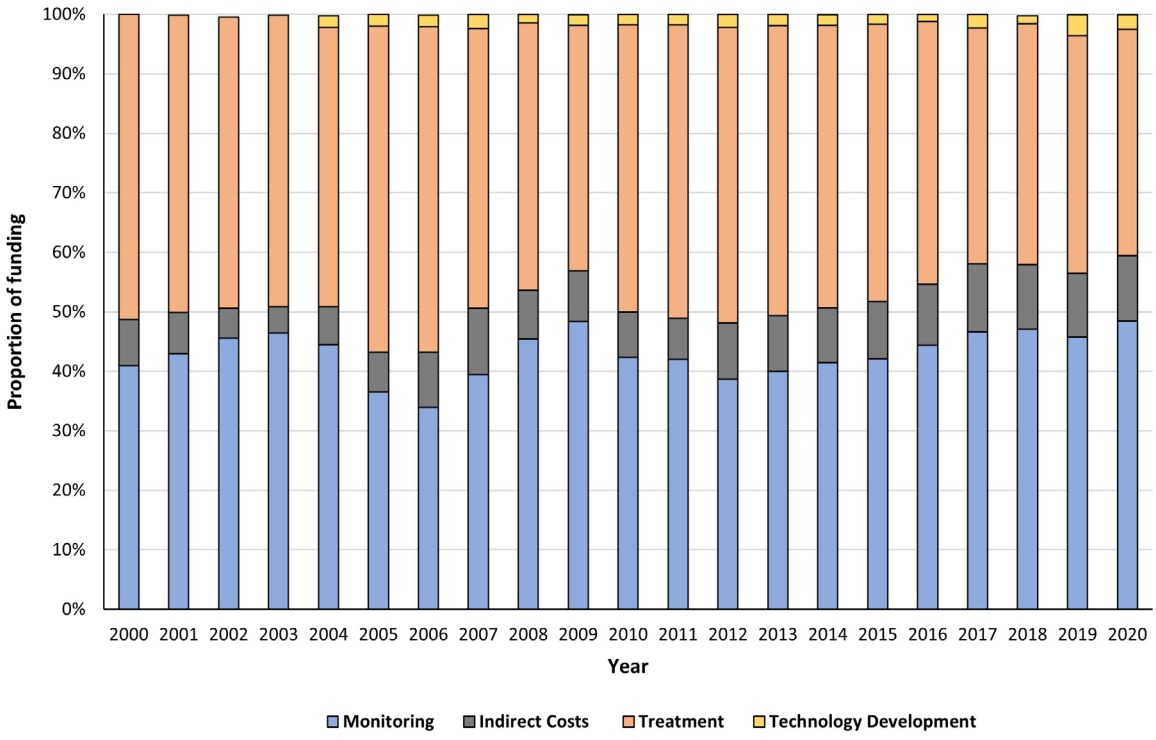

Figure 4.—Federal and state funding from 2000 to 2020 allocated to trapping and treatment activities, indirect costs, and technology development for the National Slow the Spread Program. The program has strived to maintain a 50:50 balance between trapping and treatment programs.

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APPENDIX

The following are standard protocols for implementing aerial applications for larvicide and mating disruption applications in the National Slow the Spread Program. The guidelines are updated and adapted from the Proposed Format for Technical Specifications for Aerial Application Contracts (AASC 2015).

Treatment application		
Parameter	**Larvicide**	**Mating disruption**
Number of applications	1 or 2 (second application 7–10 days after first application)	1
Timing of application	Mix of 1st instars (50%) and 2nd instars (50%) for *Bacillus thuringiensis* var. *kurstaki* (*Btk*) and *Lymantria dispar* nucelopolyhedrosis virus (NPV, Gypchek) 3rd instars for Dilflubenzuron (Dimilin 4L) 1st to 3rd instars for Tebufenozide (Mimic 2LV)	7–10 days prior to moth flight
Temperature	<65° F [primarily for *Btk*]	No application <50° F
Humidity	Preferred >60% (primarily for *Btk*)	No specification
Swath width	Varies by aircraft; ranges from 100–150 ft for helicopter and 100–200 for fixed-wing aircraft	100 ft for fixed-wing aircraft
Spray height	50–100 ft above the forest canopy	100–200 ft above the forest canopy
Nozzles or application equipment	Rotary atomizers or flat-fan/hollow-cone nozzles	Specially designed application pods
Wind restrictions	No application >6 mph (primarily for *Btk*)	No application >20 mph
Droplet sizes (volume median diameter, VMD)	124–145 microns for *Btk* (Foray 48B) 80–100 microns for *Btk* (Foray 76B) 200 microns for Dilflubenzuron (Dimilin 4L) 200 microns for *Lymantria dispar* nucelopolyhedrosis virus (Gypchek) 100–125 microns for Tebufenozide (Mimic 2LV)	Droplets (SPLAT GM-Organic) ranging from 100 to >1,500 microns
Insecticides and standard doses	*Btk* (Foray 48B, 24 (2x applications) and 36 (1x applications) CLU/ac) *Btk* (Foray 76B, 25 CLU/ac) Dilflubenzuron (Dimilin 4L, 2 oz/ac), Tebufenozide (Mimic 2LV, 4 oz/ac) *Lymantria dispar* NPV (Gypchek, 33.3 g/ac)	Hercon® Disrupt® II (6 g and 15.2 g/ac) and sticker SPLAT GM-Organic (6 g and 15.2 g/ac)