ONE TAM

Early Detection of Invasive Plants Protocol

On the Cover
Yellow Starthistle (*Centaurea solstitialis*)
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Early Detection of Invasive Plants Protocol

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Contents

Figures

Tables

Standard Operating Procedures (SOPs)

Acknowledgments

This protocol combines the work of several individuals and agencies that have devoted time to their own protocols and the development of this document. This document leans heavily on an early detection protocol from the Inventory and Monitoring Program of the National Park Service: “Early Detection of Invasive Plant Species in the San Francisco Bay Area Network.” This document was released in 2009 by Andrea Williams, Susan O'Neil, Elizabeth Speith, and Jane Rodgers. Subsequent revisions to that protocol by Eric Wrubel, Sarah Wakamiya and Allison Forrestel are also incorporated into the One Tam Early Detection protocol. Sections including SOP 3 on plant collections and vouchering include text directly from that document. Sections 2.1 and 2.2 also strongly reflect NPS protocol. The text is used with permission of the primary author, Andrea Williams. In addition to drawing from the San Francisco Bay Area Network protocol, One Tam adopted several aspects of the early detection protocol in place at Marin County Parks and Open Space District.

A subset of the contributors above comprised a guidance team for this document, known as the Early Detection subgroup of the Tamalpais Lands Collaborative (TLC). Andrea Williams, Eric Wrubel, Pete Frye, and Catey Ritchie provided guidance throughout the development of this workflow.

Field testing of this protocol in 2016 guided the development of this document by exposing areas where we needed to find consensus as a collaborative, and also where the workflows of One Tam staff need deeper documentation than might be required for a single agency. Much of this work was completed by David Greenberger, who also led field testing of Weed Manager appendices and formatted the entire document, increasing its readability and cohesion throughout.

Further contributions were made by the TLC’s Conservation Management Team, which approved the species list and other aspects of the protocol. In addition to several of the contributors listed above, this team includes Sharon Farrell, Bree Hardcastle, Mischon Martin, Janet Klein, Catey Ritchie, Bobbi Simpson, and Dave Press.

Tamalpais Lands Collaborative Early Detection of Invasive Species Protocol Narrative Version 1.2 (January 2019)

1.0 Introduction

The Tamalpais Lands Collaborative (TLC) is a partnership between the four agencies that own land on Mount Tamalpais in Marin County, California. These agencies -- the Marin County Parks and Open Space District (MCP), the Marin Municipal Water District (MMWD), California State Parks (CDPR) and the National Park Service (NPS) -- joined forces with a non-profit partner, the Golden Gate National Parks Conservancy (GGNPC), to protect the open space centered around Mount Tamalpais.

> The mission of the TLC is expressed in the document **One Mountain, One Vision**: "The TLC combines the expertise and resources of the National Park Service, Marin Municipal Water District, Marin County Parks, and the nonprofit Golden Gate National Parks Conservancy to ensure the long-term health of Mt. Tam. The TLC will advance efforts to restore ecosystems, improve trail corridors, enhance visitor experiences, expand education and stewardship programs, and inspire community support through volunteerism and philanthropy."

Among many projects and programs, the TLC's Conservation Management Team put a special emphasis on a mountain-wide early detection program. NPS and MCP have protocols and staff for performing early detection surveys on their lands. To extend these survey efforts across the area of focus, the TLC hired two Conservation Management staff in late 2015 and early 2016. The TLC also has a public initiative known as One Tam. Staff working on behalf of TLC goals are referred to as One Tam staff throughout this document. With input from the Conservation Management Team (CMT), the One Tam team adapted the National Park Service protocol "Early Detection of Invasive Plant Species in the San Francisco Bay Area Network" released in 2009. Changes suit a partnership environment and new database technology. The San Francisco Bay Area Network (SFAN) protocol is available at http://www.sfnps.org/download_product/1260/0.
It will be referred to as the SFAN protocol throughout this document.

The TLC protocol closely follows the SFAN protocol. This adapted protocol, including standard operating procedures in the appendices, do not attempt to recreate the SFAN protocol but

rather emphasizes deviations from the original. For a substantive discussion on the benefits of employing an early detection program, please refer to the original document.

Where the SFAN protocol emphasizes a volunteer-based approach, the TLC protocol reflects a staff-based, collaborative approach. The deviations presented here often revolve around the complexity of working in a partnership environment. This protocol also includes elements from a Marin County Parks and Open Space District early detection protocol. Treatment during surveys and the repetition of surveys twice in a season are specifically drawn from the MCP approach. Other decisions were made with the Conservation Management Team or iteratively as the One Tam team implemented the pilot protocol in 2016.

Given the complex partnership environment of the TLC, it is expected that elements of this protocol will be flexible in the first three to five years as priorities for surveys are defined and resources for the work grow with the evolution of the collaborative. By documenting these nuances, this document provides guidance to One Tam staff working across agency boundaries on early detection surveys.

1.1 Geography

These modifications of the SFAN protocol are relevant to the lands of the TLC as represented in the graphic below (Figure 1). Of the National Park Service (NPS) lands listed in the SFAN protocol, parts of Golden Gate National Recreation Area (GGNRA) and Point Reyes National Seashore (PORE) are included in the One Tam area of focus. In addition to those parks, Mount Tamalpais State Park lies completely within the TLC area of focus and is fully included in the partnership. Other California State Parks lands are in areas of less focus but are not included in the early detection program as of early 2017. The Marin Municipal Water District (MMWD) and Marin County Parks and Open Space District (MCP) are also TLC partner agencies. The NPS, CDPR, MMWD and MCP lands covered by this protocol of these four agencies as of early 2017 are shown in Figure 2. Approximately 36,000 acres of open space are covered by this protocol as of early 2017. As the TLC partnership evolves, One Tam early detection efforts may extend to areas of Less Focus or Future Potential shown in Figure 1.

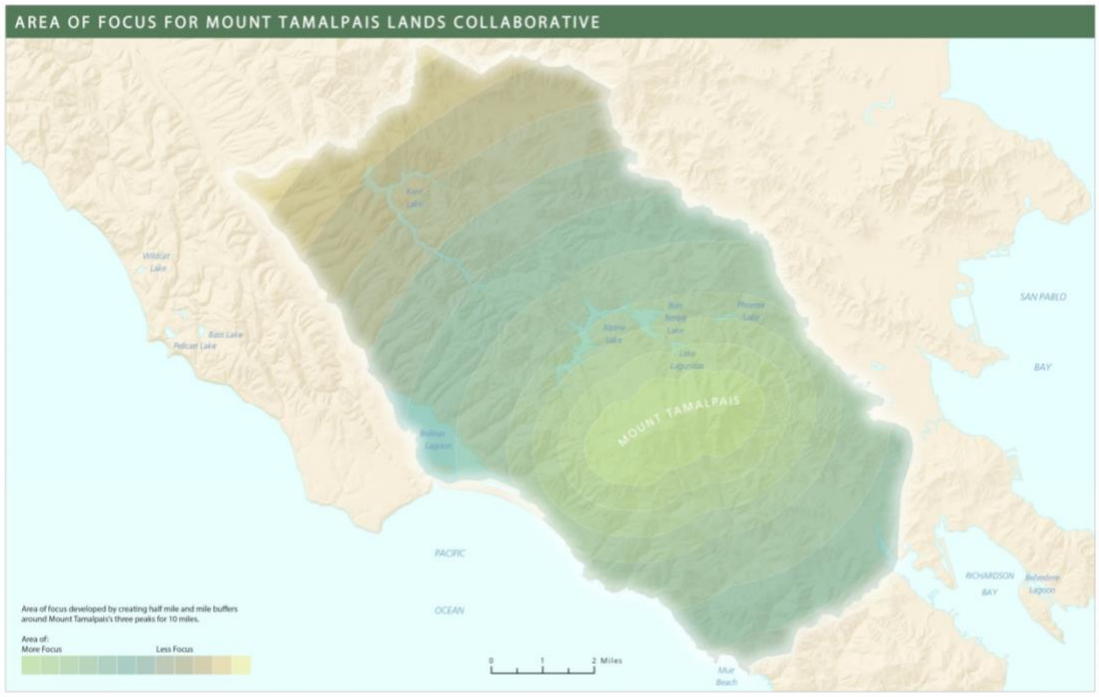

Figure 1. The TLC geography can be considered a gradient of more or less focus.

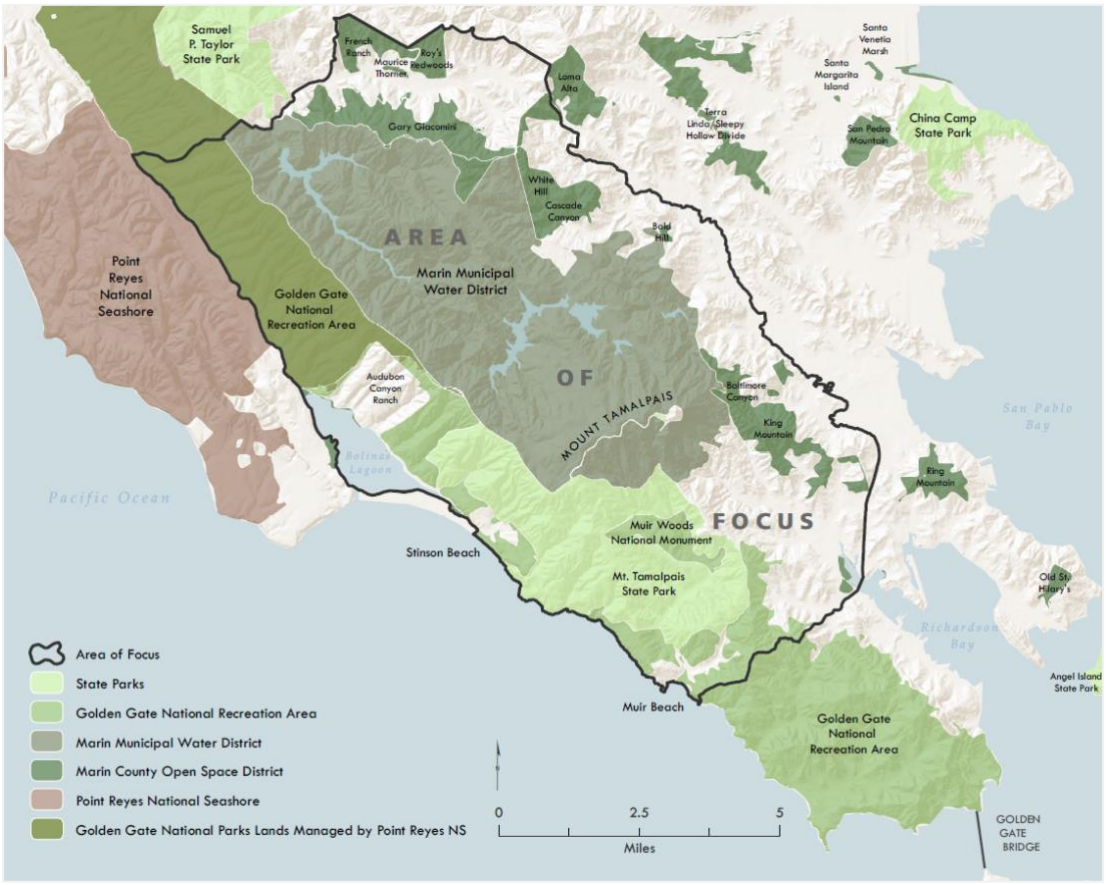

Figure 2. Four major agencies own and manage land within the TLC area of focus.

1.2 Significance to Management

Each TLC partner spends significant resources on the management of invasive species on their landholdings. Early detection of invasive plant species potentially allows for new patches or populations to be treated at stages that are most cost-effective. This TLC protocol diverges from the SFAN protocol by providing limited direction on treatment during survey work. This integration of rapid response to early detection surveys increases efficiencies. As the Conservation Management Team sought to increase capacity for surveys, there was an intentional choice to also increase treatment capacity. Treatment emphasizes the newest species in the area of focus, leaving new patches of widespread weeds to the resources of existing invasive plant management programs. Feedback loops for sharing information on new invasives are being established iteratively.

1.3 Previous Work on Invasive Plants on TLC Lands

1.3.1 Marin County Parks and Open Space District

Marin County Parks staff undertakes a wide range of natural resource management practices, including inventory and monitoring of weeds, wetlands, and special-status species; restoration activities such as invasive species control and road/trail decommissioning; and preventative measures in the form of EDRR.

Several county preserves fall with the One Tam area of focus. Each preserve is subdivided into zones by habitat quality; the One Tam conservation management team runs EDRR surveys on Natural Landscape Zones and Sustainable Natural Systems Zones, dovetailing with MCP staff-run EDRR and treatment efforts in Legacy Zones and Highly Disturbed Management Zones. The two main areas covered by One Tam are the Blithedale Ridge complex of preserves and Cascade Canyon Open Space Preserve. In both areas, ridgetop wide-area fuel breaks are the greatest source of disturbance, leading to dense invasions of French broom, as well as pampas grass, and acacia. MCP is working on strategies to manage these areas for fuel reduction in a more sustainable way.

Volunteerism is also an integral component of MCP's natural resource work, engaging thousands of participants annually. MCP first established a volunteer program in 1979 by creating the Volunteer Mounted Patrol. MCP expanded the volunteer program in 1993, when it hired a half-time volunteer program coordinator. By the mid-1990s, the program grew to include the Environmental Stewardship and Native Plant Nursery programs. Within the past decade, MCP added the Trail Watch and the Conservation Easement Monitoring programs, and the volunteer coordinator has become full time. Natural resource, administrative, and seasonal staff also support volunteer program efforts.

1.3.2 Marin Municipal Water District

Eliminating new colonies of weeds is the most effective action the district can take to preserve biodiversity (as well as reduce fuelbreak maintenance costs). The Early Detection Rapid Response (EDRR) program includes conducting regular surveys of those parts of the watershed where weed invasion is most likely, and periodic surveys in remote areas where new weed invasions are likely to be less frequent. The surveys are performed by trained surveyors including district staff and volunteers. EDRR staff, led by new seasonal aides, pull, hoe, or dig out newly discovered invasions. A database of all EDRR populations is maintained and used to facilitate follow-up visits ensuring that the invasion was eliminated. Sites are revisited and retreated annually until five consecutive years with no weed observations are recorded. The district's ongoing control of the invasive species population is accomplished through cutting or pulling invasive weeds.

MMWD's strategy also includes habitat restoration for larger areas where restoration could be effectively implemented and where funding is available. Habitat restoration and rehabilitation differs from weed control by identifying a target plant community or ecosystem function to achieve, rather than simply targeting weed(s) for elimination. Restoration actions include weed control, re-contouring slopes, rerouting trails, removing accumulated thatch, amending soils, and seeding and/or planting native species as needed. The district employs seasonal vegetation staff, uses contract crews for large-scale technical work, and maintains a robust year-round volunteer program.

1.3.3 Mount Tamalpais State Park

The vegetation management goal for Mt. Tamalpais State Park (MTSP) as a whole is to maintain a mosaic of sustainable native plant communities that 1) limit degradation due to exotic plants, 2) support sustainable populations of existing rare, threatened, and endangered species, and 3) present a park landscape of pre-historic vegetation communities to the extent feasible.

A large proportion of natural resources work in MTSP comes as a product of its membership in the Redwood Creek Watershed Collaborative, which covers land from Panoramic Highway down through Muir Woods and out to Muir Beach. This group, which also includes the National Park Service and the Parks Conservancy, enables watershed-scale EDRR, habitat restoration, and maintenance work previously untenable.

In addition to performing widespread EDRR work on State Park lands, One Tam has established a regular volunteer workday program for weed removal and trailwork through its Restoration Team.

1.3.4 Golden Gate National Recreation Area

The National Park Service has several programs working exclusively on invasive species removal and restoration of native habitat in GGNRA. The Habitat Restoration Team (HRT) began in 1992, and has grown into a large-scale invasive plant removal program. The team, and its early-detection/follow-up-focused offshoot, the Invasive Plant Patrol, have set routes and priority infestations to treat weekly in summer and monthly in fall/winter. The Park Stewardship Program (PSP), which began in 1993, is a Golden Gate National Parks Conservancy volunteer program focusing on restoration at areas of concern for endangered species within GGNRA. The Parks Conservancy runs several similarly successful volunteer groups such as Trails Forever and the Native Plant Nurseries, and also staffs a restoration technician crew for year-round work in project sites throughout the park. NPS and the Presidio Trust also manage the Presidio Park Stewards, who perform stewardship activities on Presidio lands. Larger projects often require the outsourcing of work to restoration contractors, including Shelterbelt Builders and Great Tree Tenders, among others.

NPS also runs an Inventory and Monitoring program that records data on EDRR species and plant community change. Muir Woods, Muir Beach, and some adjacent land west of Panoramic Highway partially fall under the purview of the Redwood Creek Watershed Collaborative, which combines resources to treat weeds across State and National Park land.

One Tam's area of focus includes a large swath of GGNRA land in Marin. In addition to supporting the above NPS and Conservancy teams, One Tam staff runs a dedicated EDRR program on the federal portion of Mt. Tamalpais land, and holds periodic volunteer workdays at Stinson Beach.

1.3.5 Point Reyes National Seashore

In 1989, Point Reyes National Seashore (PORE) produced an Exotic Plant Management Plan. One aspect of this plan was a ranked list identifying invasive species for early detection. In 1994, PORE established the Habitat Restoration Program (HRP). Modeled after HRT at GOGA, this volunteer group focused on high-priority species removal and limited data collection (location, species, hours worked, quantity accomplished). In 2002, PORE staff developed an SOP outlining data collection and management procedures.

Currently, projects at PORE focus on 20 high-priority species and include a 300-acre coastal dune restoration project, cape ivy control, coastal bluff iceplant removal, and jubata grass control. Jubata grass control along sensitive coastal bluffs demonstrates the high skill, and cost,

often necessary in control efforts. PORE uses a work-performed database similar to GOGA's, with initial point occurrences and UTMs entered and used to track work infestations over time.

Early detection is done on an opportunistic basis by staff and volunteers. Incipient populations of gorse, spartina, yellow starthistle, and giant plumeless thistle are controlled by staff and park partners as time allows.

PORE manages a swath of GOGA land in the northwest corner of the One Tam area of focus, as shown in Figure 2 (Pg. 3).

1.4 Collaboration

The goals of the One Tam early detection program are to identify priority invasives at cost-effective stages for treatment, treat high priority patches when possible and to share data across jurisdictions to facilitate prioritization of future work. Invasive plants often spill from one agency's land into the next, making coordinated strategies for management one approach to increasing efficiencies. Sharing techniques and resources can also improve effectiveness of treatments.

In addition to sharing data across jurisdictions within the One Tam area of focus, the TLC recognizes the importance of county-level and regional data sharing. By synthesizing information for land managers, the One Tam early detection team enables a landscape-scale approach to managing invasive plant species on TLC lands. Data sharing is primarily facilitated by the use of the publicly accessible Calflora Database as the central repository for data storage. Calflora's Weed Manager system allows agencies to record tailored data while showing subsets of information to all public users. It is readily accessible online, allowing interested parties to search for species across the state. By making location, patch size, and other data available, Calflora allows for a greater understanding of mapped species distributions than do databases housed on agency servers.

2.0 Monitoring Design

This protocol focuses on the early detection of incipient patches of weeds to prevent the establishment of new, entrenched infestations. As well-recognized vector pathways, roads and trails are the primary focus of this protocol. Because riparian corridors are also linear pathways, the protocol is also extended to those habitats.

2.1 Monitoring Questions

The primary question this protocol seeks to address is derived from the SFAN protocol:

- Where are new populations of invasive plant species becoming established along roads, trails, and riparian corridors on TLC lands?

2.2 Protocol Objectives

As of early 2017, the objectives of this protocol are as follows

1. Produce a list of target species for survey work.
2. Document survey methodology for One Tam team.

Other monitoring objectives discussed in the SFAN protocol include the prioritization of areas to survey and data analysis. These objectives should be thoughtfully discussed within the CMT toward the development of collaborative objectives and methodology. At present, each agency uses different geographical units for prioritizing surveys as shown in Table 1.

Table 1. Types of geographical units in use by agencies of the Tamalpais Lands Collaborative.

Agency	Geographical Unit
National Park Service	Subwatersheds
Mount Tamalpais State Park	Management Units
Marin Municipal Water District	Management Units
Marin County Parks	Preserves

Prioritizing across the area of focus currently relies on each land manager to put forward their survey requests based on internal prioritization. Once primary surveys of all roads and trails are complete, it will become more important to prioritize repeat surveys and return intervals across jurisdictions. The SFAN protocol provides guidance on this subject which may prove useful for the TLC to consider.

2.3 Prioritizing Species

The effort to prioritize species was undertaken by the Conservation Management Team in late 2015. This list is divided into Priority One species, which are truly new to the area of focus or the county. These species are limitedly distributed or unknown. The species on the second part of the list are known as Local Detections. These plants are widespread on TLC lands, and are often the focus of existing invasive plant management programs.

While each TLC partner has interest in species beyond the 62-species EDRR list, a choice was made only to emphasize species that would trigger management. Other early detection protocols also include presence data for all non-native plants. For efficiency, the TLC opted to only look for species that the collaborative would manage, or those that are new and may be suitable candidates for management, if found. This choice allows the One Tam team to collect

data on the same suite of species on all four agencies' lands, minimizing errors associated with shifting lists as surveys cross or straddle property boundaries.

While the SFAN protocol provided a detailed ranking assessment to develop its list, the TLC protocol relied on assessments of the Conservation Management Team. As this team includes vegetation ecologists and invasive plant managers familiar with their lands, it was assumed that the collective body could develop a well prioritized list. Some work on prioritization was referenced, such as the NPS and MCP early detection species lists and the list of the Bay Area Early Detection Network and California Invasive Plant Council rankings and alerts.

The list should be revisited annually for the first five years by the Conservation Management Team (CMT). After five years of using the list, the team can decide whether to continue to review annually or move to a biennial review schedule.

2.4 Prioritizing Geography

Prioritizing areas to survey in a partnership environment is a complex endeavor. While two agencies (NPS and MCP) have existing early detection programs with fully prioritized survey geography, the remaining agencies own more than two-thirds of the area of focus, as shown in Figure 2. Furthermore, the SFAN and MCP early detection protocols prioritize geography with similar metrics but different methods. While members of the CMT have some familiarity with lands outside their boundaries, sufficient knowledge was lacking at the outset of the pilot protocol to prioritize across boundaries in a collective conversation. Therefore the CMT allowed each agency to forward its own requests for survey geography.

With its own early detection program able to cover their network of roads and trails, the National Park Service elected to use the added capacity brought by One Tam to survey riparian corridors in 2016. Marin County Parks had a detailed prioritization schedule which would have precluded surveys in the One Tam area of focus on their lands in 2016. One Tam was able to expedite its process by performing primary surveys of trails and roads not yet surveyed within the area of primary focus. Work in Mount Tamalpais State Park and the Marin Municipal Water District revolved around areas of high visitor use or disturbance and grassland or other high-value habitats.

As the One Tam team plans for the fourth year of surveys, questions of return intervals and prioritization have emerged, elucidating the need for a comprehensive conversation about capacity and expectations. To clearly prioritize across boundaries, there is a need to identify the commitments of both the One Tam team and agency EDRR teams. The ratio of riparian surveys to trail surveys is also a question. Riparian surveys will be somewhat limited by the challenging

nature of those environments. Ratios of survey to treatment time also require consideration. In late 2018, it was decided that the team will survey on a three-year return interval.

In 2016, One Tam did EDRR surveys along approximately 75 miles of roads and trails. In 2017 the figure was 110 miles and in 2018 it was 130 miles, which closed out the primary inventory of Mt. Tam's road and trail network. In 2019, staff will work to re-survey the areas covered in 2016, as the three-year return interval has begun to cycle.

Ongoing challenges include surveying trails at different times of year to accommodate the differing phonological calendars of each target species, checking man-made infrastructure areas for weeds, and considering different return intervals for specific areas that need more vigilant attention.

3.0 Survey Methods

This protocol is intended for use by professional staff rather than volunteers. The SFAN protocol provides excellent ideas for creating a culture of early detection among volunteers and the interested public. The TLC has a robust community science program, which could incorporate early detection efforts when capacity and priorities allow. Given this protocol's suite of 62 species, many cryptic or highly uncommon, and detailed data collection requirements, this methodology is best suited for conservation professionals. Furthermore, obtaining reliable absence data for the species on the list requires a trained eye and professional commitment to the task of surveying.

Opportunistic sampling by the public or volunteers can augment these efforts. Currently the TLC uses Calflora's Weed Manager for data storage and reporting. Using the mobile application Observer Pro, opportunistic observations can be made. Using the Weed Alerts system within Calflora, One Tam early detection staff are notified when data for any species on the plant list is uploaded into the database. Use of this system is in the early stages, and has thus far only provided information on common weeds in areas where they are well known and mapped by agency staff.

One opportunity to deploy this tool more effectively lies in liaising with the mountain biking community for detections of Stinkwort (*Dittrichia graveolens)* in the late summer of 2018. This high priority species is quickly recognizable along trail sides with a late-season green when much vegetation has faded to golden or brown. By focusing on one species for opportunistic sampling, the TLC hopes to engage a user group and get a small amount of highly useful data.

3.1 Survey Frequency and Revisit Schedules

At present, all MCP surveys and some road and trail surveys for other agencies will be repeated after three months in the same year. This allows survey teams to find new infestations as seasons shift. Safety hazards and impenetrable vegetation necessitate a slow approach to riparian surveys. These will not be repeated in the same year. One Tam staff may choose not to repeat some road and trail surveys for NPS, CDPR, and MMWD. Examples of when this may occur include late surveys of grasslands in which repeats would be unlikely to yield new information (dry vegetation).

The entire road and trail network took three years to survey. As such, the return interval for the network geography is set at three years. To avoid redundant effort upon return to previously surveyed trails, the EDRR Subgroup decided in late 2018 to identify a subset of species from the target list that warrant further study. These species include *Ageratina adenophora, Helichrysum petiolare, Euphorbia oblongata, Ligustrum lucidum, Romulea rosea* var. *australis, Hypericum perforatum,* and *Tradescantia fluminensis.* These plants will be fully remapped and entered into history stacks in Calflora if prior data exists.

3.2 Gathering Field Data

Directions for field data collection are detailed in SOPs 2 and 3 and Appendix A. Surveyors work in pairs, covering a variable number of miles per day. Coverage depends on terrain, weed densities, treatment opportunities and constraints imposed by scheduling and weather. Like the SFAN protocol, a patch is considered an early detection when it is under 100 m^2 and more than 20 m from the next patch.

3.2.1 Naming Conventions

While the Calflora Database handles many naming needs internally, there remain a few elements of data storage which require naming shapes, projects, and column sets. When naming these objects within the database, begin column sets and shapes with the prefix “TLC_” to denote their use by One Tam staff. All names should be documented in the SFAN-maintained Google Sheet, Weed Manager Lists, available at:
https://docs.google.com/spreadsheets/d/1RR4UoDFdmRd6Yq9lMTBQbQ1cFGfrj-xJbe2vtSRglq8/

Weed Manager projects relevant to this protocol are found in each agency’s Weed Manager group. They are all named “One Tam EDRR.”

3.2.2 Negative Data

As discussed in the SFAN protocol, it is important for land managers to understand where a species does not occur. To get this absence or negative data, surveyors run tracklogs to record

where they surveyed. Using the Survey Entry application in Calflora's Weed Manager allows the surveyor to upload a tracklog to buffer or digitize to the site distance, creating a polygon of a surveyed area. This methodology is discussed in Appendix B.

3.2.3 Collecting Specimens

Specimens will only be collected for observations of unknown plants or plants thought to be new to the area of focus. For collection procedures, refer to the original SFAN protocol's SOP 3, "Plant Collection and Vouchering."

4.0 Data Management and Reporting

This protocol adopts many of the data management recommendations of the SFAN protocol, adapting those to a collaborative environment in which the primary users of this protocol do not truly manage the data beyond the quality control stage.

4.1 Database

This early detection program uses the Weed Manager system found within the Calflora Database, which allows the tracking of invasive plant patches or populations and treatments over time. The Calflora Database stores data using an OATS model (Occurrence, Assessment, Treatment, Survey) originally described by the Sonoma Ecology Center. Some data in this model, occurrences, assessments and treatments, can be linked together in history stacks to connect data over time. A discussion of the OATS model as it relates to Calflora is available at: http://www.calflora.org/entry/mgr/datamodel.html.

The Calflora Database is available for viewing at http://www.calflora.org/. Weed Manager is available to groups by subscription. Each TLC agency maintains a subscription to the Weed Manager system (WM). One Tam staff are members of each group. Anyone with an internet connection, including agency staff who are not part of all WM groups in the TLC, can view all population data for an occurrence -- but not treatment information, which is never made public. This is one way that the adoption of WM allows the TLC to overcome maintaining data on five separate computer servers.

In addition to viewing data, tools for searching, reporting on, and downloading data across the groups were developed for One Tam in 2016. These tools are usable by anyone who is a member of multiple groups. In this way, the tools developed by the TLC serve a smaller collaborative in the Redwood Creek watershed, which is entirely contained within the TLC area of primary focus.

In addition to desktop services in Weed Manager, the Calflora Database offers a mobile application, Observer Pro, for field data collection. This software runs on Android operating systems, including phones and tablets. Development for iOS is pending.

4.2 Data Management

4.2.1 Data Entry, Verification, and Editing

Uploading data from Observer Pro (OP) via wi-fi to WM is recommended at the end of each field day. Staff should review data daily or weekly for quality control purposes. Staff will review their own data to ensure location quality and that all attribute information is fully populated. The One Tam EDRR team functions entirely in the digital realm. This workflow increases field efficiencies, but without paper datasheets to back up data collection, quick upload and quality control measures are essential.

4.2.2 Data Archival Procedures

Data will be archived according to the internal procedures of each agency. It is recommended that data from WM be downloaded and integrated into an agency geodatabase annually or semiannually.

4.2.3 Metadata

Metadata requirements will be defined and managed by each agency as part of data archival procedures.

4.2.4 Data Analyses

Data analysis in the TLC will consist of agencies incorporating One Tam EDRR program data into their own annual analysis projects. In addition to these agency-based analyses, One Tam staff will also provide survey mileage to agency staff, as those data are not currently stored within the Calflora Database. Other data analysis will be undertaken by One Tam staff to inform the Conservation Management Team about the distributions of priority invasive species, as well as metrics on the program's functions such as labor hours and patches detected or treated. Other requests or more formal analysis schedules may emerge as the partnership grows.

4.3 Reporting

As noted in the SFAN protocol, "Data acquired from surveys may be time sensitive" (p 31). This protocol attempts to address this truth by incorporating some treatment time into surveys. Other mechanisms for feedback remain informal, with direct notification from One Tam staff to vegetation program leads comprising the primary method of communicating priorities for

treatment during the field season. A common understanding of capacity facilitates communication, but much of this feedback loop relies on professional judgment of priorities. As the collaborative grows, a system for feedback loops is warranted.

In addition to reporting to land managers to ensure timely treatment, One Tam staff shall contribute to an annual report showing the "One Tam Lift," or added value brought by collaboration and increased capacity. Metrics suitable for this report include miles surveyed, patches detected, and patches treated.

4.4 Time Tracking in Calflora

The Weed Manager system provides several methods for tracking time (Table 2). One Tam Early Detection will use Calflora to track time to feed treatment reports and other needs.

Table 2. Applications for tracking time in Weed Manager and uses by One Tam Early Detection.

Application	**Best Use for Time Keeping**
Observer Pro Form	EDRR Surveys
Hour and Herbicide Distributor	Big contractor days where you treat many (previously mapped) polygons
Plant Observation Entry HOURS drop down	Updating a few records if you forgot to take data in the field
Work Session Entry Reference record	Day-long treatments of a few large patches

One Tam will track Survey time in Work Session Entry thusly:

- Add all treatment times taken in the field using OP form in the WSE interface
- Subtract treatment time from total field time. Enter difference as "data collection" time
- One Tam will also add Drive Time and Data Management time for internal reporting needs

4.5 Revising the Protocol

This document will be updated annually for the first three to five years and then reviewed at least biennially.

5.0 Personnel Requirements and Training

5.1 Roles and Responsibilities

Conservation Management Team: Land managers and ecologists from each agency, gathered as a team, are responsible for approving survey geography and the species list. They are also responsible for reviewing this protocol and details for treatment work on their respective lands.

The Conservation Management Team (2017):

• Sharon Farrell	Vice President, Stewardship and Conservation	Parks Conservancy
• Alison Forrestel	Supervisory Vegetation Ecologist	GGNRA
• Pete Frye	Resource Specialist	MCP
• David Greenberger	Conservation Management Technician	Parks Conservancy
• Bree Hardcastle	Environmental Scientist	CDPR
• Janet Klein	Natural Resource Program Manager	MMWD
• Rachel Kesel	Conservation Management Specialist	Parks Conservancy
• Mischon Martin	Chief of Natural Resources & Science	MCP
• Josh Nuzzo	Conservation Management Seasonal Assistant	Parks Conservancy
• Dave Press	Wildlife Ecologist	PORE
• Catey Ritchie	Project Manager, Resource Conservation	Parks Conservancy
• Rosa Schneider	Restoration & Community Science Program Mgr	Parks Conservancy
• Bobbi Simpson	Liaison CA Exotic Plant Management Team	NPS
• Allison Titus	Conservation Management Seasonal Assistant	Parks Conservancy
• Andrea Williams	Vegetation Ecologist	MMWD

Conservation Management Specialist: This program manager has primary responsibility for coordinating protocol development and revision with the CMT. S/he is also responsible for overall quality assurance and reporting to the CMT when in session, as well as producing data for the TLC annual report. The Conservation Management Specialist requires moderate to high skill with plant identification, supervision, GIS/computers/databases, and writing.

Conservation Management Technician: This staff member has day-to-day responsibilities for coordinating surveys, maintaining equipment, field data collection and quality control on his/her own data. S/he also creates maps, assists with reporting and takes notes at CMT meetings. The Technician should have moderate to high skill with plant identification.

Conservation Management Seasonal Assistants (2): Assistants are responsible for field data collection, best management practices for preventing the spread of invasive plants with respect to equipment and vehicles, and quality control on their own data. Assistants should have familiarity with plant identification principles and be trained thoroughly each season on the

species list. They should pair with the Specialist and Technician for field surveys to distribute plant identification skills appropriately.

5.2 Training

Trainings for new staff will include plant identification for species on the list, including both office and field components prior to official surveys. Exercises in pacing, area estimation, percent cover estimation, and survey techniques will be taught by the Specialist and Technician annually to Seasonal Assistants. This offers an opportunity for long-term staff to refresh their own skills as they teach others. Trainings for Weed Manager and Observer Pro will also take place soon after Assistants are hired each year. Informal trainings in the field will take place as needed.

One benefit of collaboration across agencies is the opportunity for expanded training. Attending the seasonal staff trainings conducted by agencies will allow the Specialist and Technician to affirm that One Tam procedures remain consistent with agency expectations over time. They also offer an opportunity to learn new training techniques. TLC partners are exploring joint trainings, starting with public communication. Because the protocol for One Tam varies slightly from each agency to cover the changes from agency to agency, it is unfeasible to collaborate directly on teaching the protocol or use of Weed Manager and Observer Pro at this time. There remain opportunities to combine efforts on training field exercises and plant identification.

6.0 Operational Requirements

6.1 Annual Workload and Field Schedule

Early detection of invasive plants can occur year-round, but to maximize efficiencies, most road and trail surveys are conducted from March to September. Riparian surveys take place from July to October, as water levels allow. Reporting and data analysis are typically tasks for fall and early winter, with planning dominating late winter.

Table 3. Annual work schedule for the early detection of invasive plant species.

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seasonal staff												
EDRR: Roads/trails												
EDRR: Riparian												
Reporting/analysis												
Planning												

6.2 Equipment and Facility Needs

This protocol is best served by four mobile devices running Android OS and four GPS signal enhancing devices, known as pucks. Each team needs a robust hiking backpack with ample storage for carrying weed propagules from on survey treatments. Each team should have at least one hand saw, hori hori, hand pruner, and binocular set. Two radios, one per team, are required for safety. One truck with four-wheel drive and high carriage can be shared by two teams. Regular access to wi-fi, charging stations and desktop computers are also required.

7.0 Glossary

The following glossary follows the SFAN protocol (p. 42) which itself was partially adapted from Redwood National and State Parks' website, The Nature Conservancy's WIMS handbook, and the Center for Invasive Plant Management. Updates were made to include Weed Manager in the place of outdated Geoweed information.

Areas: An *area* is a uniquely named parcel of land that may have either legally defined boundaries or locally derived place names. In this protocol we will use up to three *areas* to locate each *occurrence.* Two are predefined: the sub-watershed (*e.g*. Fort Mason is in GGNRA26-3) and the site name (*e.g*. Fort Mason, Milagra Ridge, etc.). The third *area*, the *survey area*, will be mapped and documented each day as a way of showing what area was surveyed, thus showing where target species were found and not found.

Assessments: Surveys and monitoring of isolated weeds and weed population *occurrences* are defined and recorded in the database as individual *assessments*. An *assessment* therefore is a set of measurements taken over time, recorded for a specified weed *occurrence*. Each *assessment* relates to one specific *occurrence*, while each *occurrence* can accrue a series of *assessments* over time.
An *assessment* for each *occurrence* can be recorded as a point, a line, or a polygon. *Assessments* will be used to depict the size, scale, and coverage of an occurrence and therefore will be used as a basis for monitoring the project's effectiveness. The initial *occurrence* and *assessment* data will serve as the baseline for the entire project area, and the project area will be re-assessed annually for the duration of the project. These periodic *assessments* will be used to determine if weed populations are increasing or decreasing in size and distribution and if *treatments* are having the desired effects.

Invasive: Tending to spread, intrude, or encroach, usually aggressively and in an ecologically detrimental manner.

Gardeners characterize cultivated plants as "invasive" when they spread aggressively beyond where they were intended to remain, particularly if they outcompete and displace other plants in the garden. Native species can behave invasively, but this term generally connotes non-natives which can spread into undisturbed ecosystems.

Invasive species: Official term for an exotic species whose introduction can cause economic or environmental harm or harm to human health. The term originated in Presidential Executive Order 13112 issued February 3, 1999.

Occurrences: The weed *occurrence* is the basic unit of mapping and assessing a singular weed or weed population/infestation within Weed Manager. Each *occurrence* defines the presence of a single species and is recorded at a specific location. The *occurrence* location is recorded as a point in space, although each *occurrence* may actually be a population of plants covering an extensive area.

SOP: Standard Operating Procedure. These are the detailed steps explaining how to carry out the monitoring protocol.

Treatments: A *treatment* is any weed management activity that occurs at a specific time over a defined geographical area. One *treatment* may affect one or more *occurrences* (of one or several species) over one or more *areas*. The Weed Manager system tracks all types of weed control methods, including manual and mechanical methods, prescribed fire, grazing, biological control, and any chemical treatments. The database also keeps track of how much staff and/or volunteer time has been spent controlling weeds.

Weed: A weed is a plant out of place. This term is subjective; a weed is not necessarily an exotic species, although the terms are growing more synonymous. The term “noxious weed” is an official designation for weeds which cause major economic harm. Plants introduced for their ornamental, utilitarian, or food value which "escape" and disrupt natural ecosystems have only recently been recognized as weeds. More precise, accepted, and general terms for environmentally harmful non-natives are “exotic pest plant” (although “pest” has a legal definition of causing harm, similar to “noxious”) and “invasive plant species.” In Australia, exotic pest plants are termed “environmental weeds.”

8.0 Revision History Log

Previous Version #	Date	Author	Changes	Reason	New Version #
--	January 2017	Kesel, R.	Adapted from SFAN protocol	Accommodate collaborative workflows	1.0
1.0	November 2017	Greenberger, D.	Minor edits to layout, maps	New Area of Focus boundary	1.1
1.1	January 2019	Greenberger, D.	Updates to return interval and prioritization strategies	EDRR Subgroup guidance	1.2

Standard Operating Procedure (SOP) 1: Protocol Revision Log Version 1.0 (January 2017)

1.0 Scope and Application

This SOP is "stolen with pride" from the 2009 SFAN protocol by Andrea Williams, Susan O'Neil, Elizabeth Speith, and Jane Rodgers . It explains how to make changes to the One Tam Early Detection Protocol and accompanying SOPs, and explains procedures for tracking these changes.
One Tam or Conservation Management Team staff who are editing the Protocol Narrative or any SOP must follow this procedure to prevent confusion in data collection and analysis methods.
This SOP also contains a table listing the most current version of the protocol narrative and each of the SOP's. This will provide a single reference for ensuring that the most current documents are being used.

1.1 Protocol Revision Procedures

- The One Tam Early Detection Protocol Narrative and accompanying SOPs are a living document, designed to capture current best-laid plans in a readily disseminated and followed format. Changes and revisions will inevitably be made.
- All edits will be reviewed for grammatical and technical accuracy and overall clarity. Minor changes or additions to existing methods will be reviewed by One Tam staff vegetation working group and other appropriate Conservation Management Team members. This protocol should remain close to the SFAN protocol unless major revisions are undertaken with peer review.
- Edits and protocol revisions will be documented in the Revision History Log that accompanies the Protocol Narrative and each SOP. Only changes in the Protocol Narrative or specific SOP that has been edited will be logged. Minor changes, such as an alteration of species lists, will be recorded as decimal increases in version number (*e.g.*, Version 1.1 to 1.2). Major changes, such as an alteration in objectives or update after five-year analysis, will be recorded as integer increases in version number (*e.g.*, Version 1.2 to 2.0).
- Post new versions on the TLC Google Drive and notify all individuals known to have a previous version of the Protocol Narrative or SOP.

Table 4: Current SFAN Invasive Species Early Detection Protocol documents.

Document Name	Current Version	Version Date	Author
TLC Early Detection of Invasive Plants Protocol, Protocol Narrative	1.1	January 2017	Williams, A., Koenen, M., and Kesel, R.
SOP 1: Protocol Revision Log	1.0	January 2017	Jordan, J., Williams, A., and Kesel, R.
SOP 2: Mapping	1.0	January 2017	Williams, A., Jordan, J., and Kesel, R.
SOP 3: Plant Collecting and Vouchering	1.0	January 2017	Williams, A.
SOP 4: Data Management, Analyses, and Reporting	1.1	January 2017	Williams, A., Phillipi, T., Forrestel, A., Wakamiya, S., and Kesel, R.

2.0 Revision History Log

Previous Version #	Date	Author	Changes	Reason	New Version #
--	January 2017	Kesel, R.	Adapted from SFAN protocol	Accommodate collaborative workflows	1.0

Standard Operating Procedure (SOP) 2: Mapping
Version 1.0 (January 2017)

1.0 Introduction

All TLC partners are engaged in invasive plant mapping to some degree. The One Tam EDRR program will augment these efforts using the guidance below to ensure that geospatial data are consistent and interpretable. Guidance here will be limited to how to map in the field with particular emphasis on how to determine what qualifies as a patch. Refer to the SFAN protocol for a fuller description of mapping, including information on projections, datums, and spatial coordinates. Calflora data are recorded and exported in the geocentric NAD83 datum (WGS84).

2.0 Mapping Guidance

This section is taken directly from the 2009 SFAN protocol by Andrea Williams, Susan O'Neil, Elizabeth Speith, and Jane Rodgers with minor changes adopted by the TLC Early Detection subgroup of the Conservation Management Team in January 2017.

The question of "what is a patch" has troubled many weed mappers. Since the purpose of early detection mapping is to give rapid responders an idea of where and approximately how much of a priority species has been found, early detection mapping may be more gross or more detailed than desired by others.

2.1 General Guidance

- Map safely. Use your finger or a stylus to draw in points and polygons you can't or shouldn't reach.
- Map by species, not area. For each species, create a separate occurrence even if more than one species occurs in the same area.
- Inter-patch distance: Map discrete patches of a single species, unless they are closer than 20 meters apart. Separate data collection must be completed for each discrete patch.
- A patch may be an individual, a single cluster of individuals, or many clusters of individuals.
- When you see a particular species while surveying, walk out about 10 m, or until you can just see the plants clearly (whichever is closer). Walk around the edge of the patch, looking for other individuals or clusters in the same logical, topographical area. If you see more, go out an additional distance from those and continue looking. Do not record an isolated individual or a single cluster until you have determined whether other individuals occur nearby.
- Once you have surveyed the larger area, determine which cover class(es) and which distribution(s) most accurately describe what you see.
- Then fill out the form on Observer Pro, and create the polygon (using GPS when possible)
- In addition to inter-patch distance, use logical boundaries to delineate patches. Survey drainages, hilltops, meadows, or other logical topographical features as a single unit.
- The goal is to map all *occurrences* of each target species, but when determining boundaries between *occurrences* based on cover class, do not map a separate *occurrence* if one of the areas is less than

100 m^2 unless the patches are more than 20 meters apart. If only one patch occurs, map it no matter how small (unless dictated otherwise by priority level).

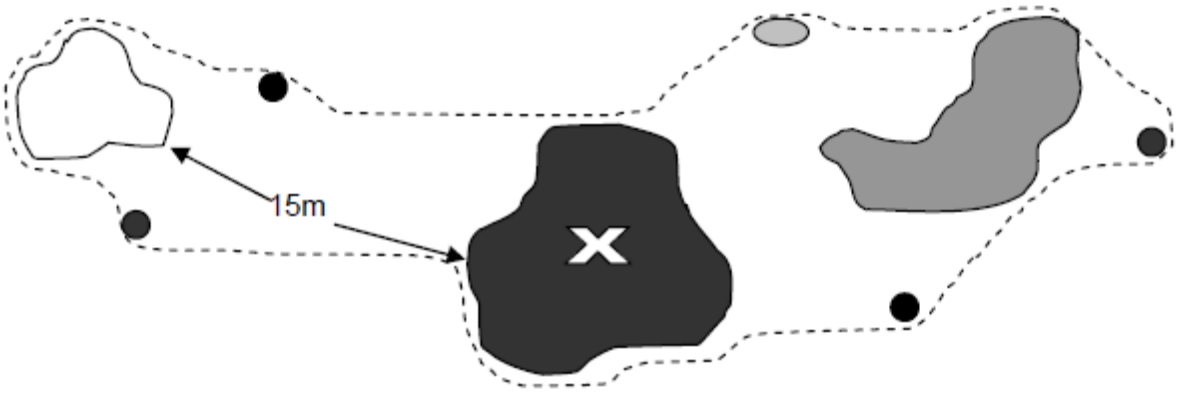

Figure 3. A theoretical mapping layout for a single species with multiple clumps of different cover classes, as shown by shading (darker color=higher cover).

The maximum inter-patch distance for the example in Figure 3 is 15 meters, so the entire area is mapped as a single *occurrence* (X) and *assessment* (dashed line) with cover of 5-25%.While this appears to miss a level of detail, one of the reasons the North American Weed Management Association (NAWMA) uses infested acres instead of gross infested acres for reporting is to account for differences in how patches are delineated. If you were to draw each clump as its own assessment and cover class, you should come up with approximately the same number for infested acres (note that midpoints of cover classes are used to calculate infested from gross infested acres) as above:

- Single assessment polygon 50m x 15m x 15% cover **112.5 m^2 infested**

- Multiple polygons

(5m x 5m x 3% cover)	0.75 m^2 infested
+ 4(1m x 1m x 97.5% cover)	3.9 m^2 infested
+ (10m x 10m x 85% cover)	85.0 m^2 infested
+ (1m x 2m x 15% cover)	0.3 m^2 infested
+ (10m x 5m x 37.5% cover)	18.75 m^2 infested
	108.7 m^2 infested

Weed Manager offers nine choices for Percent Cover:

Absent	0
Trace	0 – 1
Low	1 – 5
Moderate	5 – 25
High	25 – 50
Dense	50 – 75
Very Dense	75 – 95
Solid Stand	95 - 100
Other…	Type a number

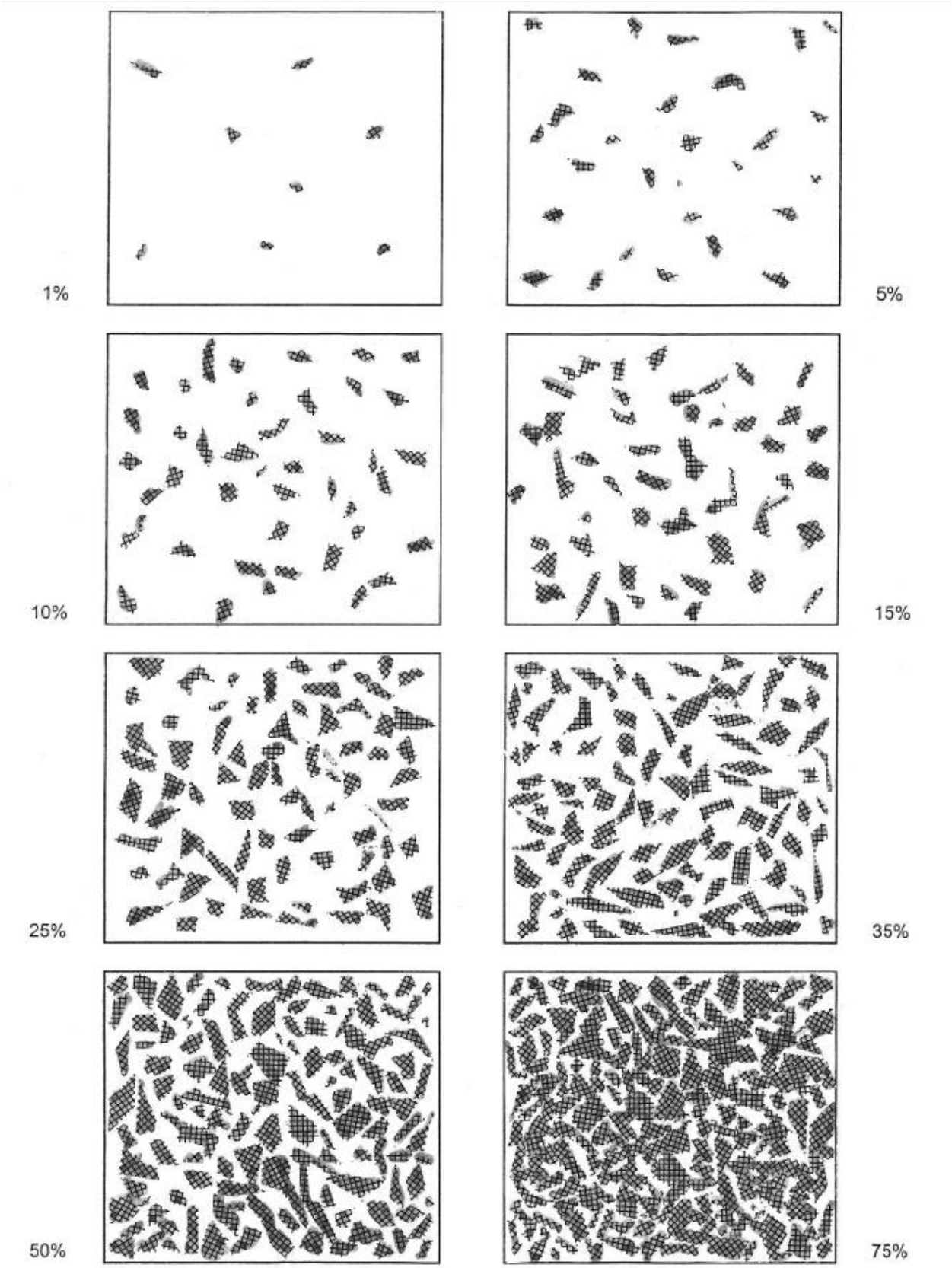

Figure 4. California Native Plant Society reference plots for cover class estimation.

2.2 Quick Reference Section

Table 5. Selections for geometry based on patch size and species priority level.

Patch Type	Geometry Type
Priority 1 species	Polygon
Priority 2 species < 100 m^2	Polygon
Priority 2 species > 100 m^2	Point in middle of patch

Inter-patch distance = 20 m

3.0 Remapping

The most recent Weed Manager data should be taken into the field during surveys as described in SOP 5 Appendix A.

When finding an infestation of invasive plants, check to see if it has already been mapped. If it has, compare the current infestation to the recorded data asking these questions to decide whether to remap it:

Is the location, size, and cover class the same?
    If no, then remap it.
Are you treating the population today?
    If yes, then remap it.

When remapping, follow the steps outlined in the SOP referenced above to create a new assessment of the patch. This will place your new data into a history stack for the occurrence.

4.0 Revision History Log

Previous Version #	Date	Author	Changes	Reason	New Version #
--	January 2017	Kesel, R.	Adapted from SFAN protocol	Accommodate collaborative workflows	1.0

Standard Operating Procedure (SOP) 3:
Plant Collection and Vouchering
Version 1.0 (January 2017)

1.0 Introduction

This SOP is "stolen with pride" from the 2009 SFAN protocol by Andrea Williams, Susan O'Neil, Elizabeth Speith, and Jane Rodgers . Having a physical voucher of a plant, especially a potentially new record in the park, remains the preferred method of proving an observation. Staff may field-key or choose to voucher for expert identification, or to record a new species for the park plant list or significant range expansion for an invasive species (*e.g.*, the first record in the county), but should also photograph the plant *in situ* to capture characteristics that may be lost during pressing. Contact park vegetation staff for a list of plants that lack voucher evidence of their presence in the park.

2.0 In the Field

2.1 Collecting Ethics and Regulations

The following does not apply if you are collecting an invasive species that you have fully identified, in which case you may collect even if there is only one plant.

Only collect if the plant's population will not be seriously affected by the taking: generally, if there are over 20 individuals in the vicinity. If the population is small, but you must collect, take only enough to key without destroying the plant (*e.g.*, a flower and/or stem without roots) and consider photo-vouchering. If plants are, or are suspected to be, rare, consider carefully whether or not to collect. CNPS, State and Federally listed species should not be collected without consultation with the park Supervisory Botanist and the appropriate permits.

2.2 Collecting Tips

Plants are best keyed fresh, so field-key when possible. Tiny-flowered plants are especially difficult to key when wilted or pressed. If field-keying is unsuccessful, press some and bag some in a plastic baggie. Blow it up with air and keep it moist (a small piece of wet paper in the bag helps); refrigeration will help keep your specimen fresh. Remember to label both the bagged and the pressed plants! A plastic sandwich container will also work well for delicate structures.

If you decide to collect with the intent of creating a pressed and mounted specimen: Collect a representative example of the species, not the largest or smallest. Try to capture any phenotypic variation.

Collect enough of the plant to make pressing worthwhile. If the plants are tiny, collect enough to fill about half an herbarium sheet. Take enough to make a good voucher, plus a little extra for keying if necessary.

Collect as much of the individual plant as possible, including roots (or a portion if rhizomatous), bulbs, vegetative parts, and flowering/fruiting matter.

Collect as many phenological stages as possible (flowering and fruiting), since many keys use characteristics of fruit and flower. If necessary, snip flowers or fruits off an additional plant to complete the collection.

Press carefully; the standard plant press is the same size as a standard herbarium sheet (11”x17”). How you place the plant in the press will generally be how it will look mounted. If a plant is large, fold it or cut it to fit, keeping branchings and general form intact. Note original dimensions and photograph if possible. Plants may occasionally require more than one sheet for proper representation.

Fill out an observation in Observer Pro with all information.

- Include Slope (in degrees) and Aspect in the notes field. You can also describe the plant in the notes field. Elevation can be calculated in the Weed Manager system.
- Print an herbarium label from the Weed Manager system.

Wash as much dirt as possible from the roots and pat dry before pressing.

If flowers are large enough, cut one or two open and press flat so the interior/cross-section can be seen. Do the same for fruits. Turn over at least one leaf so the underside will be visible in the final mounting.

3.0 Post-Collection Processing

3.1 Identify the Specimen

Do your best to identify the plant to species level; it may be a good idea to confirm this identification by asking a local expert (Vegetation Management Staff as determined) and comparing to an existing herbarium specimen or online photo (http://calphotos.berkeley.edu/flora/).

3.2 Determine Whether You Will Accession the Specimen

If the specimen meets any of the following criteria, you should consider accessioning it into the herbarium collection; if it does not then you may consider adding it to a field collection (an informal notebook or set of specimens that can be used in the field for reference) or you may discard it once you are finished identifying it for whatever purpose you had.

- Is the species under-represented (less than 5 specimens) in the herbarium?
- Does the specimen display a unique feature?
- Is this a unique voucher associated with a study or monitoring project?
- Is the specimen exceptional in some other way?
- Is there complete collection information associated with the specimen? Plants that lack location, habitat, collector and/or identifier information should not be accessioned.

3.3 Independent Verification

If plants will be verified, do not accession until they are returned. This makes loan paperwork unnecessary. A receipt for property is sufficient.

Whether or not to verify: If the specimen is to be formally accessioned, independent verification of the specimen's identity should be considered when one or more of the following conditions are met:

- There are no pre-existing specimens of the same species in the collection;
- The collection represents a new species to the park;
- Designated park staff are unable to confirm its identification with certainty;
- The specimen is otherwise unique or problematic.

Where to get them verified: If independent verification is desired for a quantity of specimens, the herbarium manager or curator should arrange for a contract through a recognized herbarium; current options include informal assistance from California Academy of Sciences, the Jepson Herbarium at UC Berkeley, or the herbarium at UC Davis. Small numbers of purported exotic species may be taken to the local County Agriculture Commissioner's Office, where the biologist will assist in identification and/or filling out a Pest Damage Record.

Documenting and packing specimens for shipping: Include proper documentation including a spreadsheet listing the specimens with collection numbers. Place a label with each specimen. You can print a label from Calflora.

Dry and press, but do not mount them. This facilitates identification.

Place them in folded, numbered sheets of newsprint, occasionally layered between cardboard, and tie the entire bundle with string to facilitate removal from the box.

Pack the box tightly to prevent anything from moving around within it.

Send it via a reputable carrier (FedEx, UPS, USPS), insured. If feasible, deliver yourself.

3.4 Accessioning the Specimen into the Formal Herbarium Collection

A collection of dried plants to be added to the parks' herbarium needs an accession number as a group plus individual catalog numbers for each specimen. Obtain these from the Museum Curator. Specimens collected as part of a study should be accessioned together, clearly indicating relevant study information. Researchers who have collected specimens under a Scientific Research and Collecting Permit must provide cataloging data in the form specified by the Museum Curator in the permit. Catalogued specimens must be entered into the ANCS+ database.

Contact the Herbarium Manager or Museum Curator for procedures and permit requirements if applicable. Remember that in entering the specimen you should be preserving the process as well as the final identification, so original identifications and identifiers should be recorded even if incorrect. Information needed for ANCS+ includes the data from the sheet above, as well as the date of any subsequent identifications and the name of the person identifying (verifying) the specimen.

3.5 Mounting the Specimen

Once specimens are identified and verified, they may be mounted. Mounting can take place before or after accessioning. Not all pressed material must (or should) be mounted: only the most complete plants, plus additional fertile material or leaf variations, should be adhered to a sheet— enough to show the plant's characteristics, but not so much as to crowd the page. Split into "a" and "b" sheets if necessary, and be sure to leave room for label information.

4.0 Revision History Log

Previous Version #	Date	Author	Changes	Reason	New Version #
--	January 2017	Kesel, R.	Adapted from SFAN protocol	Accommodate collaborative workflows	1.0

Standard Operating Procedure (SOP) 4:
Data Management, Analyses, and Reporting
Version 1.0 (January 2017)

1.0 Introduction

The Tamalpais Lands Collaborative (TLC) aims to provide and share natural resource data with agency partners to inform planning and land management both in a collaborative setting and within each agency. By sharing data the TLC is better able to develop and measure common goals, evaluate management success and assess future needs. To achieve these goals, a detailed management plan is needed to ensure data quality, interpretability, security, longevity and availability. The invasive species early detection protocol is a status-based, rapid-turnaround program. Each survey has the potential to record information that is vital to both immediate management needs and long-term analysis of invasive species distributions. Additionally, having a variety of different parks and partners sharing data makes a detailed data management plan critical.

2.0 Scope and Applicability

The procedures below cover routine data management activities for the One Tam Early Detection Program. This SOP describes how the SFAN invasive species early detection monitoring protocol, adopted by One Tam with modifications, meets data management objectives through data entry specifications, database design, quality assurance and control measures, metadata development, data maintenance, data storage and archiving, and data distribution. Data management procedures are explained for all the components of the protocol, including field data collection, data downloads, data processing and analysis, map requirements, and reporting specifications.

Data analysis and reporting are essential components to any monitoring protocol. This document outlines analysis methods, reporting timelines and materials, as well as the four basic uses of the data: the immediate reporting to management; the periodic analysis of trends in species distribution and abundance; the correlation of invasive species populations with other data (habitat, disturbance, date, etc.); and the periodic analysis of data for protocol improvement.

3.0 Description of Data Files and Database

3.1 Calflora Weed Manager Database and Observer Pro Application

Weed Manager is a data system created by Calflora for tracking weed infestations and treatments over time. Multiple agencies in the San Francisco Bay Area and throughout California also use Weed Manager, including Golden Gate National Recreation Area, Golden Gate National Parks Conservancy, Marin County Parks, Marin Municipal Water District, and the U.S. Forest Service, promoting data sharing across agencies and political boundaries.

The Weed Manager system is made up of a series of applications including:

- Observer Pro – an Android-based mobile device application used for data collection
- Plant Observation Entry – a web application for entering, editing, and viewing weed data
- Group Observations – a web application for viewing and downloading all records owned by a particular organization
- Project Setup – a web application for managing multiple projects within Weed Manager groups
- Shape Editor – a web application for viewing and editing reference lines or polygons (e.g. roads, trails, subwatersheds) as well as data spatial objects (e.g. assessment or treatment polygons).
- Work Session Entry – a web application for tracking crew hours

The Weed Manager system uses a MySQL database to store data and a web API for user interaction in the office. Data is collected in the field using mobile devices with the Observer Pro Android App. Digital data collected in the field is then uploaded to the Weed Manager MySQL database stored in the cloud. Data may be reviewed and downloaded using the Group Observations application (https://www.calflora.org/entry/groupobserv.html) while data edits are conducted using the Plant Observation Entry application (https://www.calflora.org/entry/poe.html).

In the legacy GeoWeed database, which predates Weed Manager, data were organized into *occurrences* of a species, representing the center of an infestation, which were then tied to a series of polygon *assessments* and *treatments* over time. A similar model is employed in Weed Manager, with slight modifications. Historically in GeoWeed, occurrences were always captured as a point feature while assessments were always captured as a polygon feature. Additionally, assessments were always linked to a point occurrence. In Weed Manager, occurrence and assessment data are captured on the same form and the initial detection record may be recorded as a point or polygon feature.

Some of the advantages of Calflora's Weed Manager system are:

- Digital data collection and uploading saves time over manual data entry.
- Data is easily accessible and consumable by multiple partner agencies, researchers, and the public.
- Database structure is shared by multiple partner agencies making future regional analyses more streamlined.

The user manuals for each of the Weed Manager applications may be found at http://www.calflora.org/entry/weed-mgr.html, and specific steps for using Weed Manager applications as it relates to the One Tam Conservation Management Early Detection Program may be found in Appendix B. A data dictionary for Weed Manager fields used by TLC partners may be found in Appendix [C].

3.2 Data Workflow

The data workflow for the invasive plants monitoring program of SFAN is outlined below (Figure 5). One Tam is using a similar workflow, though the team has not adopted a validation process as of early 2017. Historical data is uploaded to the tablet, followed by data collection in the field, and then the data gets processed and verified back in the office. At the end of the season, data is used to contribute to the One Tam annual report. Each agency is responsible for including One Tam data in the Weed Manager system with their own data archival procedures. One Tam does not archive any data on Golden Gate National Parks Conservancy servers.

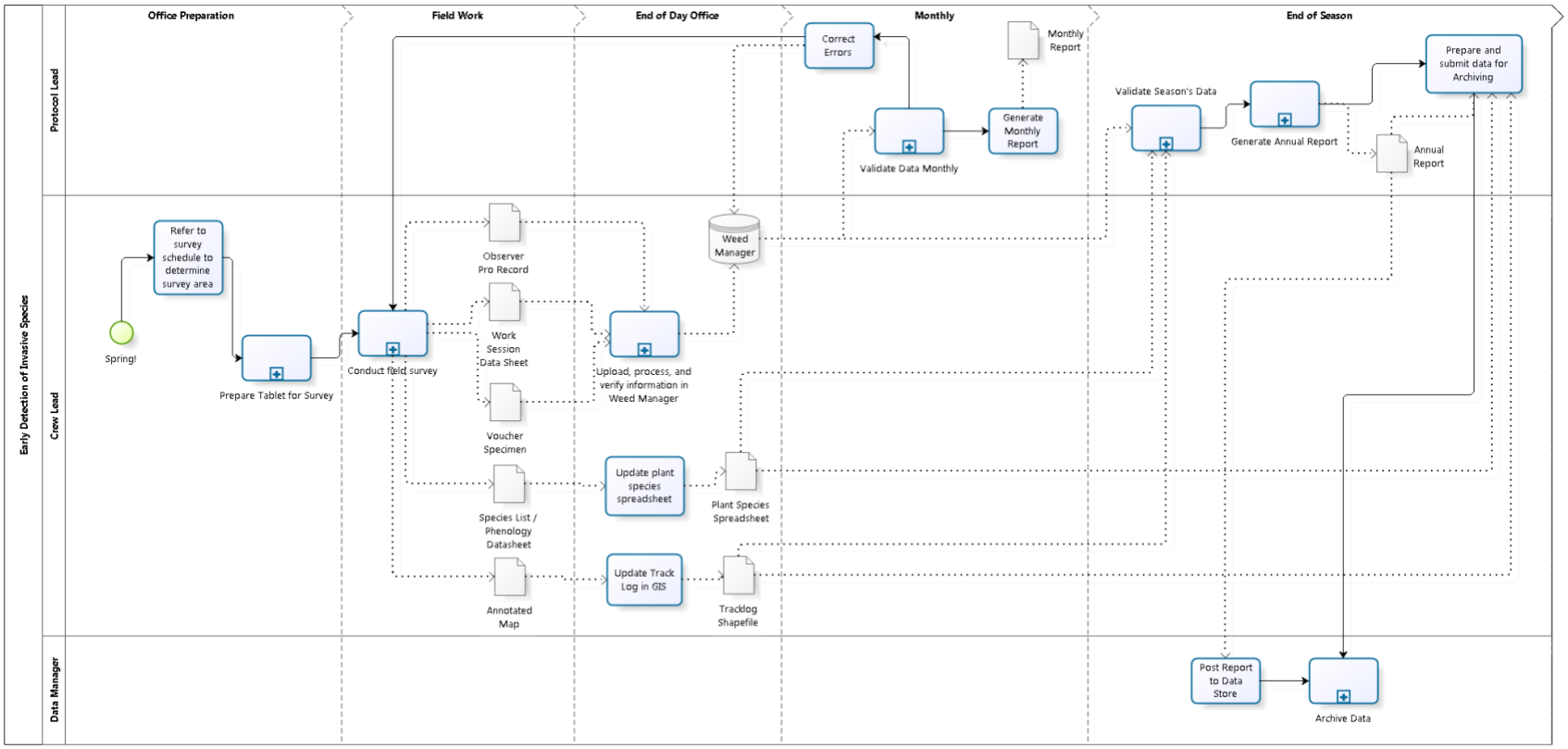

Figure 5. Data workflow model for the Invasive Plants Early Detection Monitoring Program of SFAN. One Tam uses a similar workflow which does not include paper datasheets or some validating processes as of early 2017.

3.2.1 Mobile Device Preparation and Field Data Collection

Field data is collected using mobile devices with the Observer Pro application. Prior to conducting a field visit, previously collected data can be loaded into Observer Pro. Data from the area to be surveyed is selected in the Group Observation Application. The selection is then saved in the Project Setup Application, and synced to Observer Pro via wi-fi. Specific steps for using Weed Manager applications and Observer Pro are provided in Appendix B.

In the field, data is collected on the mobile device using Observer Pro. Before leaving a patch, entries made in Observer Pro should be visually scanned to detect missing or erroneous values.

3.2.2 Data Processing, Verification, and Review

At the end of each field day, data entered into Observer Pro must be synced to Weed Manager over a wi-fi connection, or the information will only be stored on the tablet and is susceptible to loss. Work session information should be entered into Weed Manager at the end of each field day using the Work Session Entry application. In reality, work session information is often first recorded in a spreadsheet on the One Tam Google Drive. Work session information from this spreadsheet is later entered into Weed Manager's Work Session Entry application. Any voucher specimens collected in the field should be identified and their records in Weed Manager updated (using Plant Observation Entry).

Daily/weekly checks of data recorded in Observer Pro should be made in Group Observations to ensure all fields are populated. Of particular note are the area fields, which may not be auto-populated in some cases. Using the Group Observation application, the surveyor should also check the location of collected points for accuracy.

After verification, the public access permission for each record should be changed to "published" unless the record contains sensitive information. If the record contains sensitive information, the public access permission level should be set to "private." The default status of newly imported records is "unpublished." Unpublished records are only viewable by members of each Weed Manager group. Once published, the record is public and viewable by all Calflora users.

Data validation is the final step in assuring the accuracy of data and checks for systematic errors, logical errors, and outliers. Questionable data are identified, reviewed, and corrected if necessary. Some validation procedures that check the data as it is entered are built into Observer Pro/Weed Manager and will be modified as needed to improve error-checking abilities. These automatic validations are programming elements that "censor" the data based on known ranges. Examples of built-in validation include plant lists and fields that are restricted based on corresponding field values selected (e.g. the field for type of mechanical treatment can only be entered if "Mechanical" is selected in the Treatment field).

At the end of each calendar year, and on a monthly basis if time allows, agency monitoring staff may run additional validation checks and review mapping data accrued during the year. Additional validation checks are provided by an MS Access database developed by SFAN until such validation checks can be built into Weed Manager. This database allows the user to import Weed Manager data, run validation queries, find erroneous records, and provides links to the record in Weed Manager for correction.

3.2.3 Data edits after certification

Due to the high volume of data changes and/or corrections during data entry, it is not efficient to log all changes until after data are verified, validated, and considered "certified." After certification, all data edits in Weed Manager should be documented in the records "notes" field so that future data users will be aware of changes made after certification. Additionally, the metadata file associated with the file geodatabase should include a narrative explanation that summarizes what changed, when, and why.

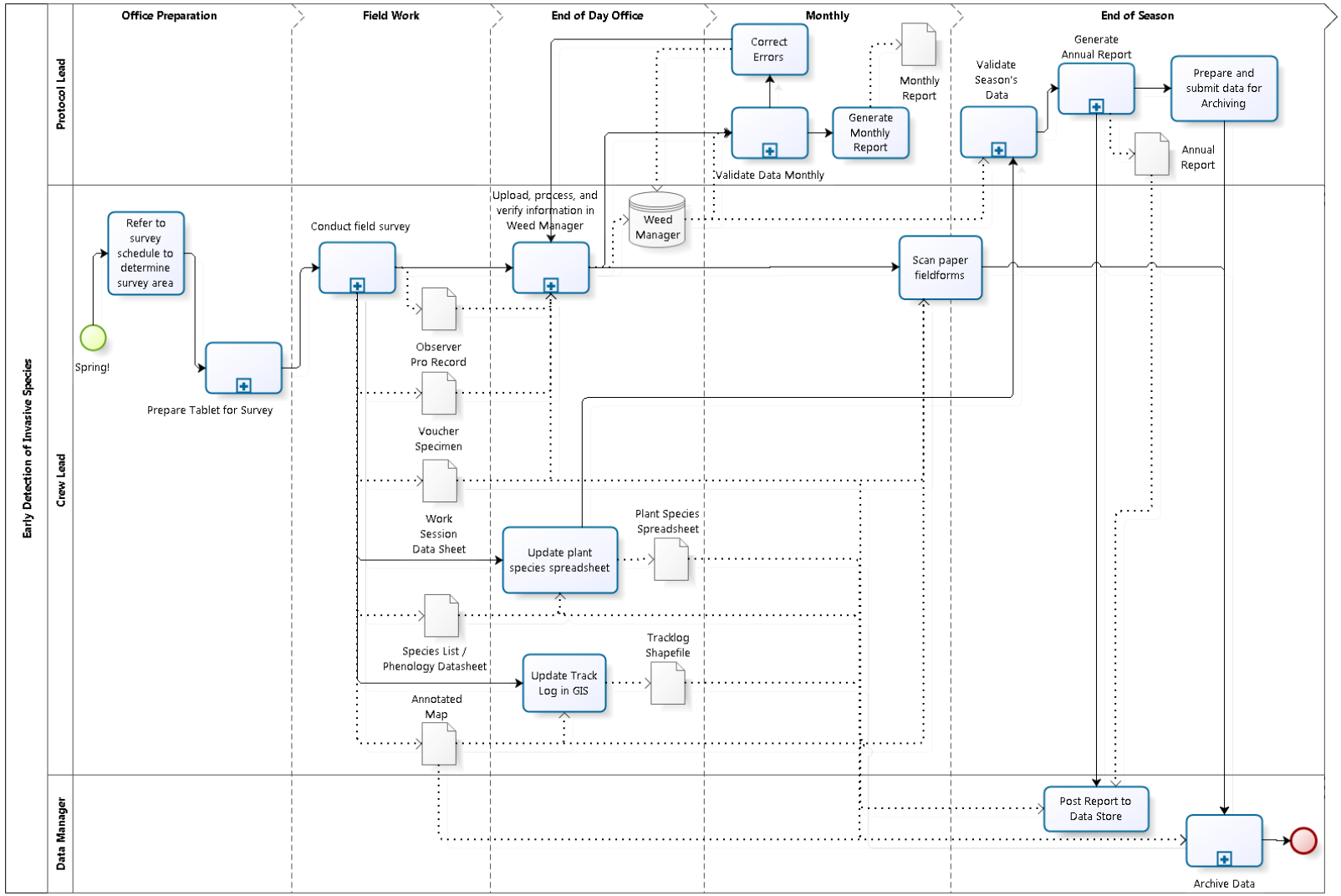

Figure 6. Workflow diagram for collecting field data in the SFAN Invasive Plant Early Detection Monitoring Program. One Tam uses a similar workflow that does not include paper datasheets or some validation processes as of early 2017. The reporting and archival procedures are performed by agency staff rather than One Tam staff.

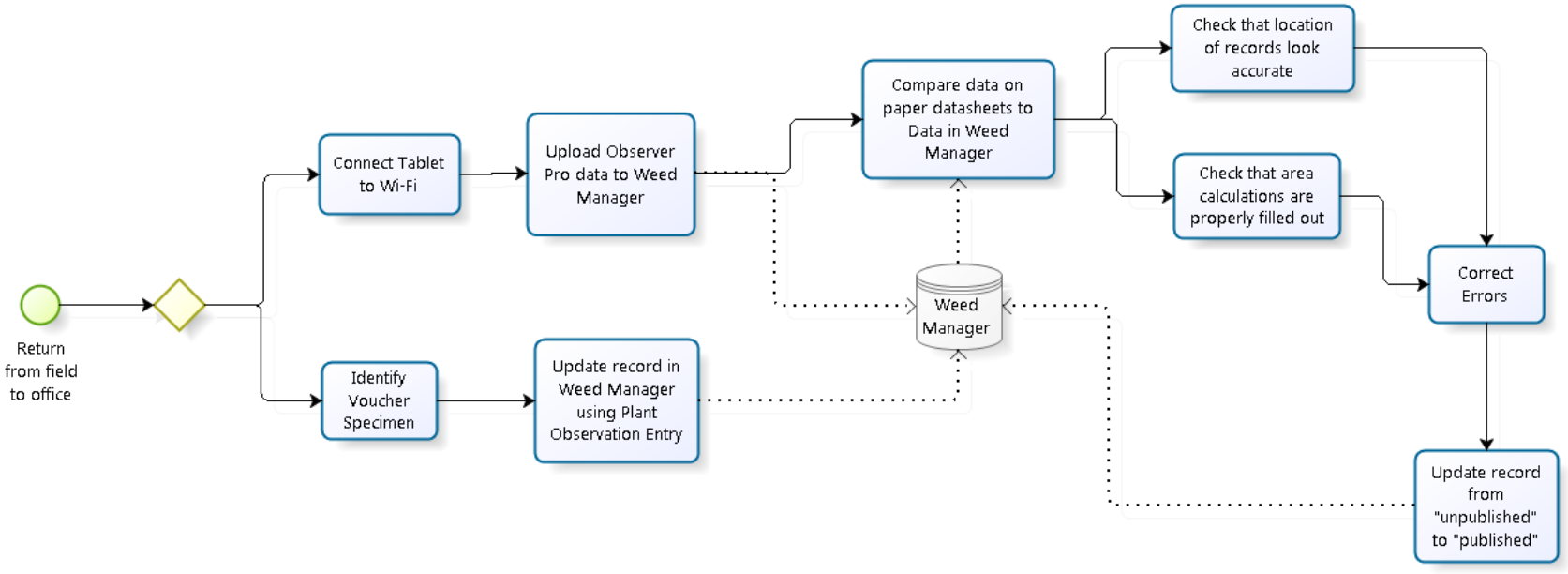

Figure 7. Workflow diagram for end-of-day office tasks for the SFAN Invasive Plants Early Detection Monitoring Program. One Tam uses a similar workflow that does not include paper datasheets as of early 2017.

4.0 Revision History Log

Previous Version #	Date	Author	Changes	Reason	New Version #
--	January 2017	Kesel, R.	Adapted from SFAN protocol	Accommodate collaborative workflows	1.0