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California Sentinel Sites for Nature Biodiversity Monitoring Workshop Gathering Synthesis Report

June 9-11, 2025

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Executive Summary

In June 2025, a three-day gathering of academics, policymakers, natural resource managers, and stakeholders from California and beyond convened to collaborate and align on the best next steps for the California Sentinel Sites for Nature (CA-SSN) initiative. The CA-SSN was born out of the 30x30 global conservation effort, designed to generate standardized, long-term climate and biodiversity monitoring data from across the state to establish the biodiversity baselines needed to track wildlife responses to climate change, land modification, and major environmental disturbance events. Before the workshop, founding CA-SSN members identified several key challenges to broad-scale implementation and sustainability of the initiative. These included the need to standardize biodiversity monitoring methods, evaluate overlap or complementarity with other programs, link the work of the CA-SSN to broader conservation frameworks, and consider how to incorporate emerging tools and technologies. Building on the success of existing monitoring protocols, the workshop aimed to outline a scalable, comprehensive sampling strategy, discuss options and preferences for analytical pipelines and data storage solutions, consider possible data products and how to ensure they are accessible, and to establish short- and long-term goals for CA-SSN. Overall, our work at this gathering reinforced the strengths of the CA-SSN, verified the general appeal of the initiative to a broad set of stakeholders, and identified actions needed to further develop the initiative over the next 18 months. These actions fall into three main themes that correspond to field methodology and standardization, raw data and analytics, and data products.

First, we agreed that implementing current CA-SSN field monitoring protocols at scale will achieve multiple positive outcomes, including providing data for groups that study and value biodiversity, supporting the 30x30 initiative, as well as the United Nation's Global Biodiversity Framework. The value of CA-SSN data products will increase as standardized biodiversity monitoring protocols are deployed at broad geographic scales. We also identified several opportunities to expand data collection, refine the scope and timing of deployments, streamline data collection and ease QC demands, and harmonize biodiversity sampling across the CA-SSN. As new technologies emerge, we also considered how they could be tested and possibly incorporated into the standard biodiversity monitoring protocol to further enrich field data collection practices and foster novel collaborations.

Second, we concentrated on the challenges associated with raw data management, storage, and curation. We prioritized steps needed to standardize data storage procedures, emphasized the importance of balancing our preference for keeping raw datasets fully intact against the expense of long-term storage of full audio and picture files, weighed the importance of storing and accessing data without expensive and energy-intensive transfers, and stressed the need to

ensure data privacy and ownership. These requirements necessitate a data platform with appropriate storage and processing power, linked to users by an interface that facilitates remote analysis. Such a platform would have the capacity to build crosswalks that make as much data as possible easily interoperable and AI-ready, and facilitate sharing, model refinement, and discoveries across teams. Such a platform will encourage users to develop common workflows to accelerate processing and analysis. Down the road, CA-SSN will also establish tutorials on accessing, summarizing, and visualizing data.

Third, we agreed to organize our network of scientists, program managers, policymakers, and community members to maximize the impact of the data we collect on biodiversity outcomes and public understanding. To realize this priority, we must create an accessible web-based platform for all stakeholders that offers an online turn-key resource to access datasets, metadata, and products derived from the CA-SSN effort. With an agreed framework to support this platform, its resources could be used to inform decision-making processes and enable high-impact research. Through this platform, the impact of the CA-SSN could also be measured by tracking data product usage. Furthermore, relevant projects and research opportunities could be announced on this platform to solicit collaborations that would target gaps in CA-SSN biodiversity assessment efforts.

Finally, a critical component of success will be maintaining collaborations to help advance the goals of the CA-SSN. To achieve this, we envision forming three high-level working groups to help tackle opportunities and solve problems related to (1) field methods and data collection, (2) raw data, including pipelines, data processing, and data products, and (3) validated data, focusing on accessibility, analytics, and use platforms. These groups will meet regularly to continue exploring issues and solutions within the three themes outlined above. Leadership within the CA-SSN will help lead these working groups to advance objectives that will strengthen the CA-SSN, increase its relevance, and ensure its sustainability.

With these themes in mind, the following report details the activities and outputs from the gathering, lays out remaining questions and ideas about designing a CA-SSN platform that maximizes our ability to objectively assess biodiversity, and charts options for the next stage of the CA-SSN's development.

Overview

Sentinel Sites for Nature (CA-SSN) Background and Identified Opportunities:

California Sentinel Sites for Nature (CA-SSN) is a multijurisdictional collaborative working to collect standardized, long-term biodiversity monitoring data across the state to establish biodiversity baselines and assess wildlife patterns over time**.** There are currently over 90 Sentinel Sites spanning nearly every ecoregion and habitat type in the state, with the majority of sites administered by the University of California Natural Reserve System (UCNRS) and California Fish and Wildlife (CDFW), as well as several additional sites managed through partnerships with The Nature Conservancy, Pepperwood Foundation, and UC Agricultural and Natural Resources (UCANR). Representatives from each partner agency comprise a CA-SSN coordination committee, which meets monthly to set priorities, strategize initiatives, and evaluate progress within the network. In general, the CA-SSN aims to provide an objective assessment of biodiversity by leveraging the talents of a diverse set of stakeholders and users that will ultimately yield clear, data-driven analyses of wildlife responses to climate change, land-use change, and extreme climate events in California. At a more global scale, CA-SSN aspires to serve as a sub-national model for other states and countries committed to increasing biodiversity, especially those participating in the 30x30 global conservation effort.

At its core, the CA-SSN consists of a network of Sentinel Sites, which are properties where standardized biodiversity monitoring and data processing protocols are implemented. Within a standard Sentinel Site, there is a weather station, a Motus tower (where appropriate), and at least four biodiversity monitoring plots. Each plot is at least 500 m apart (covering ~ 60 acres) and consists of two sound recorders (AudioMoth; one programmed to record bats, the other for birds), a traditional trail camera (horizontally oriented), and a modified camera trap (vertically oriented), installed along a drift fence to record small animals, such as herpetofauna, some insects, and small mammals. The detailed field protocols are based on the California Environmental Monitoring and Assessment Framework (CEMAF) and are available from this link: CA-SSN Existing Protocols

One major opportunity of CA-SSN is to increase taxonomic representation in our monitoring efforts. Currently, wildlife monitoring is heavily focused on terrestrial vertebrate taxa. However, the CA-SSN aims to incorporate other taxonomic groups, including microbes, invertebrates, and plants soon. Another challenge for CA-SSN is data storage and management. Data collected following the CA-SSN protocols is varied in volume, file size and type, and requires different skill sets and levels of expertise to process. There are existing protocols and repositories in place to store raw data and process validated data, and though reasonable solutions, there are obvious

limitations to their ability to support the growth of the CA-SSN and its myriad data needs. Some of the most pressing challenges the CA-SSN faces are due to the varying data types that must be managed (e.g., camera versus acoustic) and the volume of data that will be collected. We recognize that having a savvy platform for CA-SSN data will provide infrastructure that we currently do not have to accommodate many of our data streams and offer an interface for data consumers to easily find data, understand its structure, how it can be used, and provide seamless access for downloading.

Ultimately, the workshop was held to engage new participants and share current efforts to solicit feedback and potential solutions to recognized limitations and opportunities. Directed discussion was also planned to identify data solutions that would make CA-SSN data easily accessible, interoperable across the Sentinel Sites network, and sustainable, while minimizing the environmental impact of the CA-SSN data.

Biodiversity Monitoring Workshop Objectives

Through the convening of academics, policy makers, and stakeholders from within California, other regions of the United States, Kenya, and the United Kingdom, the workshop set specific objectives related to monitoring methods, novel technologies, data collection, management, and accessibility, as well as effective means to transfer knowledge. Participants worked towards developing an integrated plan that addressed these topics and provided unique perspectives on the challenges and possible solutions associated with each objective. Below, high-level objectives of the workshop are listed along with more detailed explanations to focus participant discussions.

Specific objectives:

- **Discuss standardization of biodiversity monitoring protocols:** Analyze standardized biodiversity monitoring protocols and brainstorm potential ways of adapting methods at broad spatial scales.
- **Prioritize analytical pipelines and data storage:** Discuss which analytical approaches provide a solid foundation for processing broad-scale biodiversity data, possible data formats and repositories, and determine the most likely choices for proposed data streams.
- **Consider data products and accessibility:** Develop ideas on how best to ensure data are publicly available, easy to find, secure, and that data are desirable (of high probable use) for basic research and applied purposes.
- **Share best practices:** Exchange best practices and valuable lessons learned from global biodiversity initiatives.

- **Link to broader biodiversity conservation frameworks:** Identify monitoring and analytical targets that align with the goals of the Kunming-Montreal Global Biodiversity Framework and global 30x30 efforts.
- **Incorporate new technologies:** Explore ways to integrate new technologies into biodiversity monitoring, including eDNA, drones, and artificial intelligence.
- **Discuss short- and long-term goals for biodiversity monitoring programs:** Plan next steps for remote working groups, set commitments, and create a rough outline for a publication presenting topics/ideas covered in the workshop.

CORE Institute Facilitation:

The workshop activities were facilitated by a team from The Convergence Research (CORE) Institute. The CORE Institute catalyzes an impact network of students, researchers, practitioners, industry leaders, and public policy professionals committed to engaging in research that is driven by societal problems and requires deep integration across disciplines and sectors to create solutions. CORE Institute workshops and training programs provide participants with frameworks for achieving impact through technology on the most challenging issues of our time. It is an initiative of the Societal Computing and Innovation Lab (SCIL) based at the San Diego Supercomputer Center at UC San Diego (SDSC). The Institute was launched in 2022 with support from the U.S. National Science Foundation (NSF) Convergence Accelerator.

Itinerary and CORE Institute Facilitated Breakout Exercises

Day 1

- 11:15 AM: Exercise 1 - Sentinel Site Network (CA-SSN) User Personas
    - Group 1: CA-SSN field methods and data collection personnel
    - Group 2: Research scientists
    - Group 3: Innovators in sensing, analytics, and AI
    - Group 4: Management and policy community - California
    - Group 5: Management and policy community - Outside California
- 11:45 AM: Exercise 2 - Identifying Practical Problems for CA-SSN User Personas (from above)
- 1:15 PM: Exercise 3 - Defining the CA-SSN Value Proposition

- 2:00 PM: Exercise 4 - Understanding the CA-SSN Building Blocks
    - Group 1: CA-SSN Field Methods and Data Collection
    - Group 2: Raw Data: Pipelines, Processing and Products
    - Group 3: Validated Data: Accessibility, Analytics and Use Platforms
- 3:30 PM: Exercise 5 - Global Biodiversity Framework (GBF) targets

Day 2

- CA-SSN Building Block discussion groups in the field
    - Group 1: CA-SSN Field Methods and Data Collection
    - Group 2: Raw Data: Pipelines, Processing and Products
    - Group 3: Validated Data: Accessibility, Analytics and Use Platforms

Day 3

- Presentations on Vision for Platform
    - Group 1: Future-State Journey Map
    - Group 2: Phased Roadmap
    - Group 3: Minimum Viable Product
- Discussions on Collective Impact Strategies
    - Group 1: Shared Measurement System
    - Group 2: Mutually Reinforcing Activities
    - Group 3: Mechanisms for Continuous Communication
    - Group 4: Resources for Backbone Support

Day 1

Exercises and Outcomes

Exercise 1: Describing User Personas for the CA-SSN

In this activity, workshop participants took a deep dive into the user persona groups for the CA-SSN. User personas are defined as individuals who may participate in any stage of CA-SSN implementation or seek to utilize the data and associated data products generated by the network. This exercise was focused on unpacking the goals, motivations, and values of various potential user personas.

For this exercise, persona groups were pre-defined by the CORE facilitation team and participants were split into breakout groups. Each breakout group considered the operation of the CA-SSN from a different perspective, including data collection personnel, researchers, policymakers, and others. Within these perspectives, participants imagined the concerns and struggles of particular users as a way to begin identifying standard operating procedures and design needs for improved site and network function, and to build the foundation for a CA-SSN platform for data and science collaboration and exchange.

User Personas Identified:

- Manager (multifaceted, such as natural resources manager, land manager, reserve staff)
- Field Researchers and Scientists (Biologists, Ecologists, etc.)
- Policy, Decision Makers, and Regulators
- Students (Undergraduate, PhD, etc.)
- Data and Tool Scientists (Computer, Data, Remote Sensing, Engineer)
- Sentinel Sites Local Stakeholder (growers, tribal members, property owners, etc.)
- Business/Industry Partners

Exercise 2: Identifying Practical Problems for CA-SSN User Personas

In this activity, breakout groups described the challenges and pain points for user persona groups, identifying use-inspired, concrete, and actionable problems in biodiversity monitoring.

Summarized Practical Problems (see Appendix A for session notes):

- **Managers** often don't have time or funding for data collection, to coordinate logistics with stakeholders (researchers, students, etc.), and to learn new protocols.

- **Field researchers** do not have enough time to do data analysis and synthesis from the field, require assistance with field research logistics at a site, and are unsure of how to integrate with or access other related biodiversity monitoring efforts and/or datasets.

- **Data and Computer Scientists** sometimes miss important field information when working with data (e.g., key biological information). **Ecologists** don't always understand the implications of AI workflows. Ecologists may not fully be aware of the implications of machine learning models or the computers necessary to run the models.

- A standardized, well-documented workflow must be established to ensure data gets from the field to an accessible platform to maximize data usage. **Researchers, scientists, students, and private sector researchers may** struggle to access, download, analyze, and integrate datasets without simple, straightforward directions and a clear workflow to work with and analyze the myriad data being generated by CA-SSN.

- Data are not aggregated for the specific needs of diverse users **(e.g. wine growers, agency leads, policy and decision makers).** It isn't visualized for changing policies, business, or community. Data needs to be able to quantify uncertainty and risk, and address data security rules.

- Lack of clearly defined and well-documented QA/QC processes can lead to low confidence in biodiversity monitoring data sets and/or uncertainty in how best to utilize these datasets when attempting to answer important research and management questions

- There is uncertainty around how to utilize biodiversity monitoring data for compliance monitoring. **Wildfire agencies** want to know how to integrate standard biodiversity monitoring into effectiveness/compliance monitoring. For example, after wildfires, there needs to be action on the ground quickly, but there also needs to be compliance monitoring. However, compliance monitoring is often inconsistent and underfunded. Similarly, general monitoring is not

required and typically not performed, leaving gaps in knowledge of a site before a wildfire.

Exercise 3: Defining the CA-SSN Value Proposition

Stakeholders prepared elevator pitches to describe how they imagine the Sentinel Sites transforming the monitoring of biodiversity and climate across California and serving as a model for others committed to 30x30. Full narratives are available in Appendix B

Co-Created Group Pitches on Value Proposition:

Group 1: Field Methods & Data Collection

- Audience: Local land stewards/ranchers
- Focus: Stewardship, land restoration, and conservation
- Emphasis on *monitoring* and *technology* (scale, frequency)
- Framing: CA-SSN as a guiding effort for government & local action
- Vision: CA-SSN can help "save the world"

Group 2: Research Scientists

- Audience: Scientists, policymakers, managers
- Focus: Biodiversity loss with human/ecosystem impact
- Emphasis on *data*, *consistent methodology*, and *statewide coverage*
- Framing: Informing conservation decisions, early detection of ecological change
- Vision: A *template* for other states and countries

Group 3: Innovators in Tech/AI

- Audience: Tech and conservation decision-makers
- Focus: Crisis in biodiversity, data overload without action
- Emphasis: Converting data into usable insights
- Framing: CA-SSN *Consistent monitoring*, *best practices*, *protocols*
- Vision: Make California a leader in biodiversity innovation

Group 4: California Policy & Management

- Audience: California public and policymakers
- Focus: "Pulse of nature," real-time assessment of natural resources
- Emphasis: Real-time understanding of natural resource health
- Framing: CA-SSN provides *trustworthy*, *scalable*, *community-accessible* data

- Vision: Improving lives and showing leadership on a global stage

Group 5: National Policy Audience / General Public

- Audience: Taxpayers
- Focus: Tracking health diagnostics for the environment
- Emphasis: Pieces of information on nature, analogous to data on human health metrics or automobile diagnostics
- Framing: *Baseline data*, *collaborative*, *trend detection*
- Vision: Maintain environmental "systems" and detect problems early

Key themes that emerged from this exercise include:

- Technology and data integration (mentioned in all groups);
- Actionable data for conservation (groups 2, 3, 4);
- Scalability and CA-SSN being a model (groups 2, 3, 4);
- Public engagement and accessibility (groups 1, 4, 5);
- Leadership and innovation (groups 3, 4);
- Early detections, having a pulse on nature (groups 2, 4, 5);
- Collaborative and trustworthy (groups 4, 5);
- Biodiversity as vital to human/ecosystem health (groups 2, 3, 5)

A unified version of the five value propositions that brings together the themes the groups landed on could be:

California Sentinel Sites for Nature (CA-SSN) is a statewide network using advanced sensing technologies and consistent data protocols to monitor biodiversity at an unprecedented frequency and scale. By providing reliable, real-time ecological insights, CA-SSN empowers land stewards, scientists, managers, and policymakers to detect early signs of environmental change and take timely conservation action. Designed to serve communities locally while setting a global example, this collaborative framework ensures that biodiversity can be monitored for decades and ultimately protected for generations to come.

Exercise 4: Understanding the CA-SSN Building Blocks

Participants rotated through three focused discussion groups to share core design considerations when developing a data system for biodiversity monitoring. Each discussion group was centered around a different aspect of the CA-SSN protocol, with the three topics

being (1) standardized field and data collection methods, (2) raw data – pipelines, processing, and products, and (3) validated data – accessibility, analytics, and use platforms. Thoughts and suggestions shared by participants were summarized by discussion group topic.

1. ***Discussion Group 1: Field and Data Methods***
    - Standardized protocols need to be durable, clear, and consistent (in regard to metadata), flexible (to unique users and diverse lands), and should be established with a wide variety of expertise.

    - When thinking about flexibility in protocols, we need to ask: What kinds of data can be collected? What monetary resources are available? Which sort of users can or are able to deploy certain equipment? What equipment is accessible and affordable?

    - Questions remaining: What is the minimum amount of data being collected? Will certain machine learning models that we use to identify species become obsolete in a few years? Should we even be collecting this data in the first place? Is there redundancy in data collection? Who has agency over what data? Are we respecting the rights of people who will be impacted by this data (e.g., land stewards, tribal nations). How are we thinking about the full life cycle of data collection?

2. ***Discussion Group 2: Raw Data: Pipelines, Processing, and Products***
    - Data challenges: large, high-volume data sets, unreliable mechanisms for transferring the data, long-term storage, security of data, version control, bandwidth, lack of shared guidelines between some of the raw and processed data.

    - There should be:
        a. Capacity and expertise to process raw data.
        b. Scalability: Decreasing need for human validation, automating processes, reducing the volume of data, collecting data for a strategic reason.
        c. Need to consider different users and how they will likely differ with the scale of use, data generation, processing requirements, etc.
        d. There needs to be interoperability between datasets (at different locations/symptoms) For instance, how do you make sure that the

camera data from a specific monitoring site can be easily linked to the acoustic data from that same location even though the data reside in different repositories? How do we make sure that that is clear?

- Remaining Questions: If data starts to live in a lot of different places, how do we know who is managing it on different platforms? How do we control quality and privacy? Is there a standardized validation procedure for all different data types?

- Data Product Suggestions:
    a. Sensitive species data (from agency/regulatory side) made available in a timely manner.
    b. Data product that quantifies how well the AI models are performing (measuring accuracy) so researchers and policy makers can feel confident about the data/models.
    c. Packages that can pull down data subsets and collate them depending on the user's needs.
    d. Raw Data: documentation that allows a researcher to re-evaluate the data in the future for another reason than why it was originally collected.

3. Discussion Group 3: Validated Data: Accessibility, Analytics, and Use Platforms

- There should be:
    a. Data storage for 10, 20, and 1000 years.
    b. Displays of modeled outputs to avoid showing restricted information. There should be living dynamic distribution and occupancy maps of California for all detected species. They should be updated annually to generate metrics of richness.
    c. Analysis of economic trade-offs and ecosystem services.

- Challenges: There are restrictions because of certain data (e.g. sensitive species), uncertainty in analyzing and visualizing data, and there is tension between building centralized platforms versus the complexity of different datasets.

- Remaining Questions: Who in the legislature do we need to look at this?

Exercise 5: Kunming-Montreal Global Biodiversity Framework

Participants formed groups and collaborated to identify how their work aligns with any of the Kunming-Montreal Global Biodiversity Framework targets (GBF targets). They were then asked to consider how CA-SSN biodiversity monitoring data could be used to track short- and long-term progress towards their identified GBF targets. The identified targets and ideas on how to apply CA-SSN data are provided in the following table.

Identified Targets of Relevance	*Ideas for applying CA-SSN data*
T1: Plan and manage to reduce biodiversity loss *T2: Restore 30% of all degraded ecosystems* *T3: Conserve 30% of lands, waters, and seas*	CA-SSN data could be used to help evaluate the impact of restoration activities
T6: Reduce the Introduction of Invasive Alien Species by 50% and Minimize Their Impact	CA-SSN data could be used to help track the presence of invasive species and gauge the success of mitigation management efforts
T2: Restore 30% of all degraded ecosystems *T10: Enhance Biodiversity and Sustainability in Agriculture, Aquaculture, Fisheries, and Forestry*	Need to consider how we incorporate working lands into CA-SSN. Metrics and data from CA-SSN could be used to track positive outcomes of working lands, show their benefit.
T13:Increase the Sharing of Benefits From Genetic Resources, Digital Sequence Information and Traditional Knowledge *T20: Strengthen Capacity-Building, Technology Transfer, and Scientific and Technical Cooperation for Biodiversity* *T21: Ensure That Knowledge Is Available and Accessible To Guide Biodiversity Action*	(i) CA-SSN should develop knowledge to guide action in decision-making in cooperation with community partners. What are the best practices across those partners? (ii) Decision support theaters: can a platform forecast models of development or disturbance as a result of restoration? Can it assess threats, hazards, and risks? Can it demonstrate connectivity across time and space? Can we quantify biodiversity value for wider audiences? Can we track use cases for data over time? Can we share this infrastructure with other partners?

	(iii) We can use CA-SSN to inform more public access and value for biodiversity. Efforts can be integrated into school curriculums (e.g. sample datasets for school use in science curricula, audio tracks for learning).
T20: Strengthen Capacity-Building, Technology Transfer, and Scientific and Technical Cooperation for Biodiversity *T21: Ensure That Knowledge Is Available and Accessible To Guide Biodiversity Action* *T22:Ensure Participation in Decision-Making and Access to Justice and Information Related to Biodiversity for all* *T23: Ensure Gender Equality and a Gender-Responsive Approach for Biodiversity Action*	Protocols should maintain data sovereignty and privacy. Who owns the data and who has access to what? How do you decide who you share data with?
All identified targets	Recommended data sets: statewide occupancy maps, genetic distinctness, early detection of invasive species records.

Day 2: Quail Ridge Site Visit

Day two of the workshop included a field trip to Quail Ridge, a Sentinel Site managed by the UC Natural Reserve System, to learn about the site's complex ecological and geographic characteristics, to consider challenges with monitoring in remote regions, and to receive an overview and visual demonstration of select CA-SSN monitoring components, including cameras, sound recorders, and a weather station. In the later part of the day, participants were divided into one of three discussion groups based on their area of expertise or interest (in line with group breakouts from exercise 4 on day 2; i.e., field methods, raw data, validated data) and asked to explore a series of questions specific to their discussion group. The prompts were designed to prime participants for the exercises they would complete on day 3 and to help them begin formalizing a group presentation they would give on day 3. Thus, the takeaways from these discussions are reflected in content from day 3. Here, we simply provide the prompts that were presented to each group.

Discussion Groups:

1. **Group 1** - **Standardized field and data methods:** What opportunities do you see in the current protocols based on today's visit? What are the best practices for ensuring protocols are well-documented, adoptable, and sustainable across the network? How can we ensure interoperability between data collected from different sites and methods?

2. **Group 2** - **Data pipelines, processing, and products:** What challenges do we foresee in processing and managing the types of data in the CA-SSN? What kinds of data products would be most valuable to different users? How can we ensure scalability and interoperability across the network? How can we enhance data processing pipelines?

3. **Group 3** - **Data accessibility, analytics, and use platforms:** How can we design analytical tools and dashboards that support the needs of different stakeholders? What compute resources or architectures will be needed to support broad-scale biodiversity analytics across the network? What are the key principles we should follow to make data FAIR (Findable, Accessible, Interoperable, Reusable)?

Day 3: Future Vision and Collective Impact

These exercises drew from the previous days' discussions to develop broad visions for the CA-SSN and milestones to measure success over an 18-month period. Participants remained in their groups from the previous day and collaborated to prepare two presentations – a vision presentation and a collective impact presentation. The work completed on day 3 incorporated persona group uses, identified steps for refining the data pipeline with an associated timeframe, and envisioned the necessary components to produce a CA-SSN platform for users that would support a community interested in biodiversity, open science, and the broadening and refinement of the scientific practices used to collect, manage, and use data at Sentinel Sites. Participants discussed ways the vision for a common agenda and shared metrics could be achieved within the CA-SSN. To enable collective impact, activities, mechanisms, and resources were identified that could align efforts and leverage participant strengths for CA-SSN backbone support. The slide from each presentation are provided in Appendix C.

Visioning Presentations

Group 1: Future-State Journey Map

Group 1 was tasked with envisioning how the various user persona groups identified on day one of the workshop would potentially interact with the CA-SSN and how knowing user actions could help guide CA-SSN strategic developments. The group selected a subset of user personas and explored what data or information these users might be interested in and for what purpose. Selected user personas included a policy maker, research scientist, university professor, and restoration ecologist.

Through this exercise, the group was able to identify specific challenges that the user personas may encounter when utilizing CA-SSN protocols, data, and data products, and subsequently identified ways to address these challenges. The recommended solutions, described in more detail below, include key features of a future CA-SSN platform, important reference material that will be needed for different audiences, and approaches for simplifying data access and analysis for the research community. The recommendations that resulted from this exercise can be used to chart a course towards the future state of the CA-SSN envisioned by this community.

User Persona: ***Policy Maker***
Goal: Decide whether to fund for the next 2 years

Actions	*Solutions*
Learn about the CA-SSN program	*Visit the website for an easy to follow overview*
Deepen their understanding and ask questions	*Get a presentation/pitch; CA-SSN has a clear communications plan for funders/policymakers*
Need a way to evaluate if it is worth continuing investment	*CA-SSN develops an impact report and business case*

User Persona: ***Researcher***
Goal: Data to analyze biodiversity patterns in California

Actions	*Solutions*
Find the data	*A good website and visibility e.g., through conference presentations*
Understand if the data are fit for the purpose	*Get a preview of the data, clear metadata, and link to publications/reports that describe data and power analyses*
Easy way to download and analyze the data	*Simple download instructions and R tutorials, linked datasets, and clear citation requirements*

User Persona: ***Lecturer***
Goal: Data to support a biodiversity module for an undergraduate program

Actions	*Solutions*
Find the data	*A good website and visibility e.g., through conference presentations*
Easy access for students	*Vignette that describes how the data can be retrieved and analyzed in R, slide deck for a class based around CA-SSN data, and an education and outreach role within CA-SSN or link with existing educators.*

User Persona: ***Restoration Manager***
Goal: Replicate CA-SSN protocols to assess the effectiveness of restoration

Actions	*Solutions*
Implement management that is site specific, and impact on protocols	*Guidance/case studies on how to do this*
Understand how long to monitor for	*Refer to publications/reports on efficacy and power, strengths and limitations; point to contact(s) for guidance, drawing on CA-SSN experiences*

Take Home Recommendations from Group 1:

- Develop a communication plan
- Create a website that is easy to use and access
- Perform a pilot data power analysis
- Create resources for educators
- Ensure there is good documentation on how to download, use, and cite CA-SSN data

Additional Ideas and Feedback from Participants:

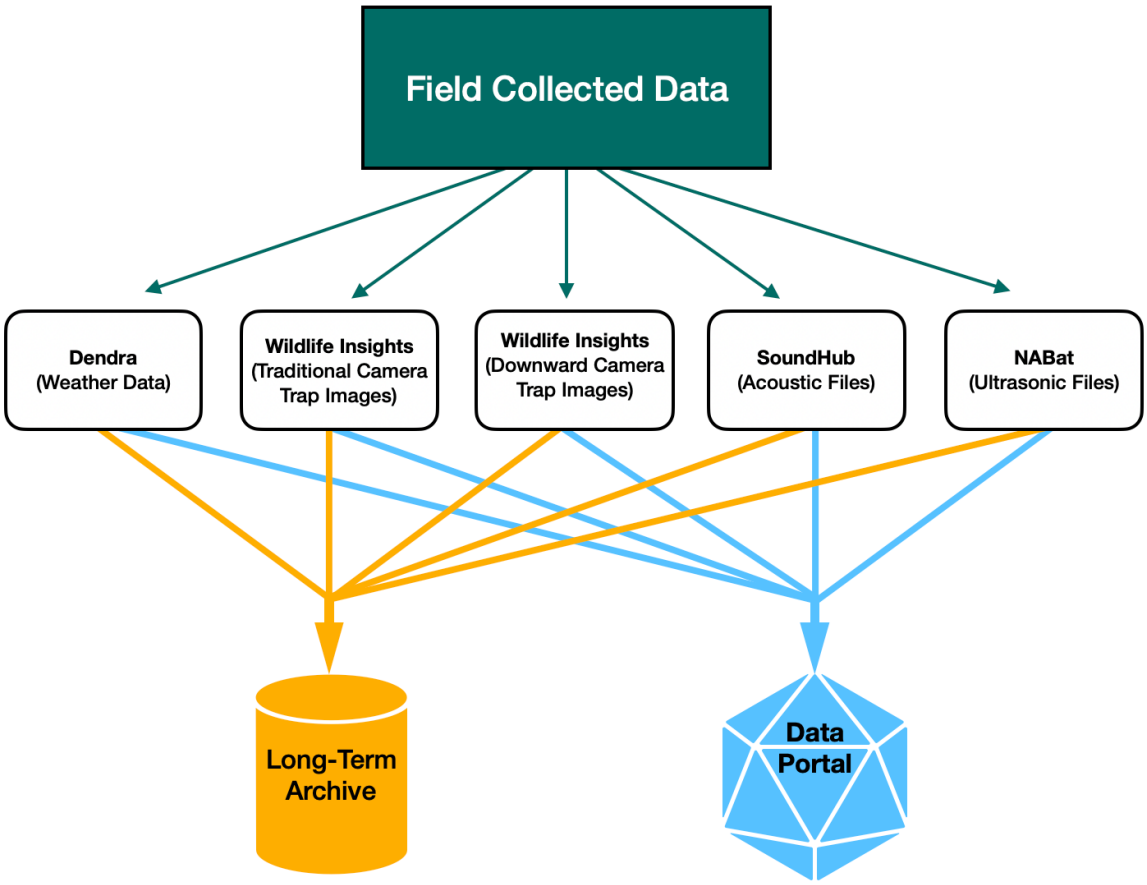
- Suggestion to envision the restoration manager persona as any land owner
- Consider how you make public interaction meaningful within the CA-SSN and ensure data are accessible (e.g. neighbor who wants to set up cameras in the yard for CA-SSN involvement)
- Consider creating impact reports for policymakers and offering solutions in them.
- Determine how we make resources available for sites (e.g., lidar, community science Work, etc.)? Researchers need comprehensive pilots (from deployment to data collection) to consider what kind of sampling is needed that may not yet be understood, and they need easily accessible data to begin analyses.

Group 2: Phased Roadmap

Group 2 was tasked with identifying key components of data collection, processing, analysis, storage, and access relevant to the CA-SSN and the current challenges with managing, curating, and storing data. They then created a roadmap of major tasks and milestones associated with these components and a proposed timeline for implementation in 2025-2026. The full CA-SSN protocol, which details associated field methods and equipment required to align with minimum monitoring standards, as well as data processing procedures, is available via CDFW's

protocol page. As a reminder, the biodiversity monitoring data consist of camera images, sound files, and migratory data via Motus towers deployed at sentinel sites, where appropriate. Camera trap images are uploaded to Wildlife Insights, which is considered the long-term repository; SoundHub will serve as the repository for all acoustic data; the NABat (North American Bat Monitoring Program) Bat Population Database is the designated repository for bat audio recordings. Dendra is the repository for climate data being collected via weather stations at sentinel sites.

Group 2 generated the following schematic to illustrate the ways CA-SSN data are archived in repositories or planned to be managed, and how a web-based platform might interface with these datasets.



For the second part of their presentation, the group presented phased roadmaps for data collection and processing, and data access and analysis.

The proposed timeline for the **Data Collection and Processing Road Map** outlines the following milestones:

October 2025*:* Protocol establishment for metadata, data formats, and ancillary information
April 2026*:* Data ingestion pipelines for each repository; data-specific submission and processing guidelines
July 2026*:* AI/ML processing pipeline development; data-specific AI/ML code-model;
October 2026*:* Data validation; AI/ML validation
December 2026*:* Finalize

The proposed timeline for the **Data Collection and Processing Road Map** outlines the following milestones:

December 2025*:* Data integration with a system; determine necessary authorizations and access type
July 2026*: Data search enabled; feasible to search by location, time, and data type*
December 2026*:* Community research exchange; have a Github, registry, research ID exchange, and publications list on the site

Additional Ideas and Feedback from Participants:

- There are differences across the tools/data repositories in terms of what they do (e.g. processing). Missing on the diagram is MOTUS, which is a core component of the current protocol, and ways to incorporate new data, such as eDNA, insect diversity data, and vegetation data
- Create a painless, clear workflow for data validators. What is the minimum level of validation?
- Needs appropriate authorization for data access and user interface.
- Was the taxonomic group considered? Should we start by binning those for confidence intervals? For example, If we know the machine learning model is 98% accurate, then there shouldn't be a worry.
- The questions and directions of CA-SSN should be integrated through platform transparency.
- The governance committee decides how CA-SSN will ingest new measurement tools or sensors.
- Sound recordings pick up people. There needs to be intentionality about this.
- The user persona who wants the raw data has different problems than the other user persona group.

- There is a big middle area for the broad biodiversity goals and the metrics to provide to policymakers.
- Need to relate field groups to protocols for data collection - metadata, devices, formats, ancillary info (field notes). Related to field setup. Like, do we want something about your placement that we didn't tell you?
- Data ingestion pipeline - repo - by type. Get this all fleshed out. Repo by type. Don't want anyone confused…how to deal with wave files? How will it actually work?
- Need data-metadata integration between the systems

Group 3: Minimum Viable Product

In this presentation, Group 3 identified the core needs of a CA-SSN platform, imagining all the components necessary to create a successful platform for all user personas. The group noted all the features and components that might be built if we had unlimited time and resources. With this, the group pitched a minimum viable product that could be produced by the Sentinel Sites.

The immediate **Must-Have Products** identified included:

- A **data portal** that is searchable, findable, and equipped with filters;
- An interactive **map**;
- **Educational materials**, such as **tutorials** for data use and processing;
- **Citation tools** and instructions on how to cite CA-SSN data;
- **Visualization tools** and data use tools;
- **Success stories** and a **photo gallery**;
- **Reporting tools** for government and agency staff;
- A **charter** that includes governing structure;
- **Data use policies** for all communities;
- Directions on **how to join CA-SSN** and a way to connect through a **discussion board**;
- **Dashboards** that provide a target for user journeys;
- A **welcoming home page**

The **Should-Have Products** identified included:

- Some **integration with citizen science** platforms;
- **Highlights of success stories**, specifically people or nature-based stories;
- **Search feature** with custom indices;
- **Open research questions** for the community of stakeholders;
- An "**Understanding Changing Biodiversity" tool**;
- **Curated data bundles**;
- **Links to existing solutions** and options from other sources;
- **Automated data summaries**;

- **A "State of Nature" report** for government officials

The **Could-Have Products** identified included:

- An index or **scorecard for environmental/ecosystem health**;
- **User social network**;
- **Print version of data products** or key stories;
- **User outreach activities** to non-domain users;
- **Podcast** and other online presence (marketing, generally);
- **Test beds** established for new sensors and data products;
- **Model validation tools**;
- **Chatbot** to find data and educational materials;
- **Corpus data scraping**,
- **Digital twins**;
- **Automated interpretation of data** sources;
- **Data exploration through a GUI** or interactive map;
- **Expert network**;
- **Automated data summaries**;
- **Automated data uploads to API**

Recognized **Won't-Have Products** (for now) included:

- **Visualized prediction models**;
- **Public Information** on health, economics, threats, and opportunities;
- **Forecasting tools**;
- **Data storytelling** and big picture metrics;
- **More CA-SSN stations** with targeted sampling;
- **Raw data access**;
- **CA-SSN conferences** for public, government, and science personas

Taking all these realizations and molding them into a minimum viable product, it was determined that the CA-SSN needs to immediately develop a web portal and online presence focused on interactive access to reliable data, community connections, education materials, and storytelling. The key features that must be a part of this are:

The inviting **homepage**;
A basic **interactive map** of California that provides access to data overviews and products;
Data descriptions;
Search features for existing data that offer filtering and download options;
Basic visualization of data for one key use case;
Tutorials on how to access and work with the data;
CA-SSN **site establishment guidance**;

Introductory set of **inspirational stories** with photos and highlights

Additional Ideas and Feedback from Participants:

- We should broaden our work to people who are doing economic or agricultural forecasting as use cases.
- Re-insurers: bring an CA-SSN representative to one of these insurance events.
- Not all data needs to be downloaded, but all data needs to be accessed.
- Digital twin for forecasting: to show a use case (i.e. Maori wetland, showing past, present, and future). General predictive models are also digital twinning. The real-time integration of this is unique.
- State legislators should see a scorecard of how they are doing.
- Search filter data component (for research community), front-facing homepage (CMS), social media/interactive website (for community of practice).
- Governance structure: need this for software development and for CA-SSN.
- We need to figure out what the description of data means and looks like.
- Can we understand from the traffic that comes to the website to query what people want? You must make sure this platform is accessible to a lot of people- user testing with 8-25 people.
- Sampling is done on durably protected lands, skewed to 30x30—therefore, researchers and policy makers will use it right away. Then you can branch monitoring outside of protected areas (i.e., agriculture). However, if you want to eventually get more public groups engaged, you should start to build the infrastructure for public engagement (create a figure to implement this-then get funding).
- Outline the phases

Collective Impact Exercise

Participants, having reached consensus on the vision for a common agenda that guides the next phases of development for the CA-SSN, were split into four groups and tasked with (1) identifying a set of metrics that would showcase engagement within the CA-SSN, (2) activities that could maximize impact, (3) communication strategies that would engage various sectors and promote sustained involvement from a wide breadth of stakeholders, and (4) ways to establish a backbone to support the technical needs of the CA-SSN.

In summary, Group 1 focused on creating a common framework for tracking progress. Their actions centered on quantitative metrics, qualitative and usage-based metrics, tracking user

types, metadata and data infrastructure, and temporal and spatial alignment of data. Group 2 focused on coordinated outreach, education, and participation with core actions such as planned engagement through media and collaborative events, educational tools and tutorials, building partnerships to increase collaborations, efforts to broaden inclusion, and interactive content. Group 3 focused on continuous communication mechanisms that would build trust and alignment. Core efforts discussed included public-facing channels (e.g., social media), internal communication tools (e.g., Slack, listservs), participatory governance, and clear documentation and guidance for data collection and processing. Group 4 considered operational, technical, and governance infrastructure, with a focus on technical systems, data governance and policies, staffing, physical infrastructure, organizational committees, and ease of data access and use. Detailed actions brainstormed by each group are listed below.

Group 1: Shared Measurement System – A common set of metrics is used to track progress. In this section, stakeholders emphasized measures of engagement with the platform and its data, ranging from tangible and direct engagement (volume of data shared, number of active users) to measures of broader influence (citations to the platform) to evidence of widening awareness (internet search traffic for CA-SSN and the platform).

Actions to center on include:

- # of sites deployed
- Volume of data
- # of top “interested” collaborators
- Distribution of use
- # of partners with data entering repositories
- Sampling across different land ownership types
- Followable SOPs
- Scopes accumulated
- Data access requests
- # of user types/diversity of partners
- Species/organismal accumulation curves
- # of contributing partners
- # of support requests by step/pipeline
- Measure SOP adoption
- Citations, references, media articles
- Google searches of CA-SSN
- Provide a partner satisfaction survey
- # core FTE staff
- Reliable, consistent geographic, and spatially subdividable metrics
- Ancillary data; climate datasets and remote sensing
- Alignment of dates for data with different temporal characteristics
- Crosswalk metadata with unique IDs for observations and structure to indicate plot, site, etc.

Group 2: Mutually Reinforcing Activities – Participants coordinate efforts to maximize impact. In this section, stakeholders focused on outreach to drive up membership outside the platform (newsletters, demo days at Sentinel Sites, citizen science opportunities) and digestible content that would keep existing members engaged with the community and its impact (photo galleries, reports from working group meetings).

Mutually reinforcing activities identified:

- A guide with links on how to get specific data (including associated data streams)
- Tutorials (i.e. NEON) with codes to visualize, access, and summarize the data for 2-3 common reporting needs
- Citizen science
- Photo gallery
- Policy reports
- Outreach with stakeholders
- Visual identity
- Pipelines for groups to use parameterized reporting (based on dynamic data and maps)
- Partnership with NGOs to pilot work and shape participation
- Coordination with other biodiversity networks (national and international) on protocols, goals, engagement, etc.
- Broadening participation committee
- Peer review systems for data
- Setting a mandatory quota for volunteer work
- Newsletters
- Working group meeting summaries for CA-SSN network
- Outreach education workshops, training early career researchers
- Demo days to connect with users
- Rotating schedule to discuss different sites at monthly meetings
- Have working groups report out in standard bullet format
- Local informal meetups of group members
- Software workshops and user feedback sessions

Group 3: Continuous Communication Mechanisms – Mechanisms for open and transparent communication build trust and help maintain focus and alignment. In this section, stakeholders focused on public-facing communications and events, such as annual meetings, alumni events, and social media presence, on support functions such as office hours, and on layered structures of participation for improvements, such as micro-committees and democratic decision-making institutions.

Continuous Communication Mechanisms Identified:

- User-defined index with applied data
- Public trust mandate and regulatory conservation guidance (CDFW, UC, CSU)
- Platform for communication (e.g. Slack)
- Communication committee to develop and implement communication strategies
- Democratic decision-making processes
- Annual meetings
- Social media
- Sharing buddies/micro teams to regularly meet and exchange information/ideas
- Detailed instructions for sampling methods and raw data collection with information on on-site storage and best practices
- Alumni events
- Office hours
- Contacts lists

Group 4: Backbone support – Support and coordination. Here, stakeholders focused on technical support (website hosting, bug and issue tracking, programming support), support for data hosting and licensing, and overall site governance.

Backbone Support Identified:

- Governance policy
- Data management plan, including licensing, ownership, citation, and agreements
- Central and distributed data storage
- Programming, AI, and technical support
- Fiscal Sponsors and managers
- Issue tracking for queries, bug fixes
- Equipment installations, maintenance
- Permanent staff
- Website hosting
- Easily access coordinates and data
- Time of data collection range
- CDFW and UCNRS collaboration
- CA-SSN Network office
- Data Committee: evaluates protocols, hosts regular meetings on data ingestion and output, hosts data challenges across sentinel sites
- Policy Engagement Committee: interface with policy makers, contribute to reports

In summary, the core ideas that emerged from the Collective Impact exercise highlight the need for building a robust, transparent way of measuring and monitoring engagement, data quality and scientific impact across the CA-SSN; coordinating strategies and content that will help grow and strengthen the CA-SSN; creating transparent and inclusive communication structures that will promote engagement and alignment across stakeholders; and establishing best-practices that will ensure sustainability of the CA-SSN through supported systems, clear governance, and durable technical infrastructure.

Conclusion and Next Steps

At the close of the workshop, there was a palpable sense of excitement around the CA-SSN and strong interest from participants to continue the work that was begun at the start of the workshop. Numerous short- and long-term opportunities were identified over the three days. Prioritizing these is an immediate goal of the CA-SSN Coordinating Committee. The work commenced right after the workshop ended, with most of the Committee meeting to discuss take-aways and next steps. Over the next eight weeks, the Committee will rank to-do items and determine how best to complete them.

All agreed that development of a web-based platform that provides CA-SSN users with a simple access to reliable data, a community of users, documentation, and PR materials, is essential to the success of CA-SSN. In collaboration with the UC San Diego Supercomputer Center, an effort is underway to build and pilot a CA-SSN platform that will begin to provide many of these key features. Over the next six months, we will seek volunteers to help test and validate this platform with a focus on providing high value to a diverse community of users. Follow-up efforts by workshop participants will be crucial for producing interactive maps, creating educational materials and tutorials, providing stakeholders with success stories, building reporting tools, establishing just data use policies, and constructing a website that is welcoming, with dashboards, and directions on how to join and participate in the CA-SSN.

Ther CA-SSN Chair will solicit participation in three working groups that will operate under the themes of (i) Standardized Field and Data Methods, (ii) Raw Data - Pipelines, Processing, and Products, and (iii) Validate Data - Accessibility, Analytics, and Use Platforms. Working groups will convene monthly work sessions with the CA-SSN Coordinating Committee to develop and advance strategic initiatives. Working group members will also be invited to join the Sentinel Sites Roundtable (a part of the California Biodiversity Network) and provide updates at their bi-monthly meetings. Once working groups are

formed, the CA-SSN Chair will make a formal announcement to all participants and assist with coordination kick-off meetings.

Finally, it is important to reflect on the framework that was proposed during this workshop to increase the collective impact of the CA-SSN. Participants suggested a comprehensive and coordinated framework that invokes four major principles. First, there must be rigorous measurement, based on a shared system of metrics to track participation, contributions, visibility, and satisfaction to ensure there is transparency and strategic alignment within and among CA-SSN working groups. Second, there must be coordinated engagement that fosters participation through educational materials, outreach events, and strategic partnerships. This will reinforce shared goals via interactive and inclusive outreach. Third, CA-SSN participants must model transparent communication and inclusive decision-making processes to build trust, disseminate knowledge, and support ongoing collaboration. Finally, there must be a strong backbone of support for maintaining technical, organizational, and policy infrastructure to ensure reliable operations, data integrity, and long-term sustainability.

As we strengthen and build out the CA-SSN, we are committed to ensuring collaborative governance, scientific integrity, community engagement, and long-term project resilience. In doing so, we aim to create a model that sets a precedent for global standards of biodiversity monitoring. It is our hope that you will join in this effort.

Appendices

Appendix A: Identifying Practical Problems for User Personas

Practical Problem	***Stakeholders***
Managers don't have funding for data collection and equipment can be stolen.	***Manager***
It is difficult to standardize data protocols when sites are dynamic and diverse.	***Manager, Researcher***
Managers struggle with advanced data storage protocols without training of new systems.	***Manager***
Managers don't always have the time or money for additional tasks like monitoring. Sometimes they aren't available to perform time sensitive monitoring tasks.	***Manager***
Managers sometimes work with unsafe and vandalized equipment.	***Manager***
Senior Natural Area Manager doesn't know how to present uncertainty and risk in the observation and action plans for improving habitat.	***Manager***
Managers need access to real time data around species records.	***Manager***
A manager living in a rural area has limited internet connectivity.	***Manager***
Senior staff are unsure of abilities and needs of inexperienced in field data collection.	***Manger, Field Researcher, Students***
Field scientists do not have enough time to process data from the field season before the next field season hits (creating backlog)	***Researchers***
Computer scientists and PhD students sometimes create technical tools that are advanced but not applicable to ecologists and other users. Jargon can become confusing. Data scientists can miss important biological information and timelines of data collection. Metadata is not always standardized or clear.	***Computer Scientists, Data Scientists, PhD students***
Metadata is hard to find or not standardized for researchers.	***Researchers, Scientists***
Field research scientists collect multi-species data, but they do not necessarily have the expertise to complete ID for all species detected	***Researchers***

(e.g. CA-SSN acoustic data, ultrasonic photos- mammals, herps).	
Sometimes researchers struggle with the logistics of study design because of a lack of understanding of a site and/or its protocols. For instance, sometimes there are difficulties with the study of land inaccessibility (private land).	***Researchers***
There is no standardized pipeline of workload, to cleaning the data, to processing it, to storage, and to usability. Researchers, scientists, post-docs, and private sector researchers struggle to access, download, analyze, and integrate datasets.	***Researchers, Computer/Data Scientists, Students,***
Relevancy: Data isn't aggregated for the particular needs of different users (e.g. wine growers, agency leads, policy and decision makers). Data isn't aggregated or visualized for changing policies, business, or community. Data needs to be able to quantify uncertainty and risk, and address data security rules.	***Local Stakeholders, Policy and Decision Makers***
Field researchers don't always have clear direction on what data is most useful for informing decisions across their agency.	***Researchers***
When responding to wildfire there needs to be action on the ground quickly but there needs to be compliance monitoring. General monitoring is not required and often ignored because of a lack of funding and capacity. Compliance monitoring is also often inconsistent, underfunded, and non-repeatable. Wildfire agencies want to know how to integrate standard biodiversity monitoring into effectiveness/compliance monitoring.	***Researchers, Wildfire Agencies, Policy and Decision Makers***
The camera trap window misses key phenology.	***Researchers***
Researchers can't estimate abundance (e.g. 5 trees or 50 trees).	***Researchers***
Researchers are unsure if monitoring data is enough to infer about the ecology of the site (does there need to be other data such as experimental, traditional ecological knowledge?)	***Researchers***
Researchers are concerned that monitoring does not show enough information about interactions because it only takes photos rather than videos.	***Researchers***
Researchers experience logistics barriers for their research. These logistics include; access to sites for installation and research, determining where to install devices, lack of funding to purchase appropriate equipment. Ecologists want to know what CA-SSN methods are the right ones to use for their site for monitoring. CA-SSN Staff don't always have the time to support researchers.	***Researcher, Managers, CA-SSN Staff***

Population biologists don't know if camera traps are representative or poorly placed.	***Researcher***
Ecologists don't have an easy way to know what threatened species could be introduced in this area.	***Researcher***
Undergraduate students cannot wait 3 years for data from collaborators for their senior project.	***Students***
Rotating funding results in high staff turnover	***CA-SSN Staff***
Need an opportunity to present CA-SSN staff (e.g. webinar) to those who work in collaboration with them (students, researchers, etc.).	***CA-SSN Staff, Researchers, Students***
Data scientist experiences error propagation and uncertainty from data → model → interface → prediction	***Data Scientist***
Remote sensing scientists need to resolve point data, discrete samples, and continuous optical each with varying resolutions, extents, accuracy and precision.	***Scientist***
Funding is for fieldwork and time for data cleaning. Funding for analysis and synthesis is scarce.	***Researcher***
Researchers utilize different coding languages which can make interoperability and standardization difficult.	***Researcher, Computer and Data Scientist***
When beginning to study a taxon not currency studied at the CA-SSN site, deciding on the sampling site, the researcher will stand the test of time with long term monitoring.	***Researcher***
There is no plant, fungi, or insect data for ecological research.	***Researcher***
Bat ecologists work with large datasets with no freely available way to process data and there is very little funding.	***Researcher***
Those who lead and receive training need the time and availability to do it.	***CA-SSN Staff, Researcher, Student***
Sometimes those in the network feel their species of concern isn't being monitored by CA-SSN. For instance, field researchers cannot detect herps and reptiles because the camera traps are heat-based.	***Researcher, Local Stakeholder***
Computer scientists and academic professionals don't understand timelines of data gathering in conservation contexts. They often ask, when will this data be available?	***Computer and Data Scientists, Academics***

Decision makers don't have access to "gold standard" synthetic data products that translate easily into "ecosystem health" due to lack of scientific consensus on what indicators of taxa/species are most important to track.	***Policy and Decision Makers***
Lack of short-term data to evaluate ecosystem health and biodiversity for decision makers.	***Policy and Decision Makers***
Agency leader needs real time understanding of outcomes from policy and does not have time to wait for lengthy studies and data collection	***Policy and Decision Makers***
CA-SSN network is uncertain in regards to how CA-SSN monitoring will provide progress updates to reaching statewide biodiversity goals (30x30).	***CA-SSN Network***
Agency leaders have no time to use data analysis tools to inform decision making.	***Agency Leaders***
PIs don't have funding for monitoring work.	***PI***
To make decisions related to biodiversity, state legislators need stories that work in short sound bites that align with their values.	***Decision Makers, Researchers, Local Stakeholders***
Rural, natural resource business owners (timber) need to plan for future business, understanding what will be the effects of climate and biodiversity on the local economy for my business. The owner needs local economic metrics that will help them decide how to manage forest for sustained harvest while maximizing 30x30 and conserving local wildlife. They need to know what the costs/benefits are in real money.	***Local Stakeholders***
There is no baseline for biodiversity and climatology data. For instance, PhD students don't know what data is available.	***Students, Researchers***
Ecologists don't understand the implications of AI workflows. Ecologists may not fully be aware of the implications of machine learning models or the computers necessary to run the models.	***Researchers, AI experts***
Loss of personnel due to funding has resulted in the loss of institutional knowledge.	***Researchers***
Need expertise to evaluate outputs of AI classifiers.	***Researchers/Scientists***
Researchers are unsure of how to use data with limited reference or baseline to compare to and understand trends.	***Researchers***

Data from the past may not be interoperable with new tools.	***Researchers, Data/Computer Scientists***
It is hard to scale biodiversity metrics because you need experienced individuals who can "ground truth."	***Researchers***
Memory storage is an issue for audio files.	***Researchers***
Computer science PhD students struggle with communicating confidence of their SDM results due to bias in site selection data.	***Scientists***
Wine growers need to manage irrigation water supplies, but environmental data is not aggregated for that.	***Local Stakeholders, Researchers***
Ecologists are unsure how they can integrate their data from their site with CA-SSN data.	***Researchers***
Some CS/AI professionals don't know what some words and data points mean. There is a disconnect in language.	***Researchers/Scientists***
Sometimes a natural corridor on a CA-SSN site is blocked by private land. Sometimes wildlife will break down the fence or barrier between CA-SSN and private land, damaging property. Sometimes the animal is killed as a result of this. Usually there is no compensation and community members become agitated.	***Initiative leaders, Local Stakeholders***
There is no baseline/historical data for climate change modeling for researchers.	***Researchers***
Needs to be able to visualize and use the data.	**Researchers, Students**
Needs to be easy to navigate and understand available data	**Researchers, Students, Policy Makers**
Need accessible usability of automated tools (e.g. WI, Animal, BirdNET, Sonobat)	**Researchers, Students**
Need to receive training for site research	**Researchers, Students**
Need login credentials to access datasets (all sizes).	**Researchers, Students**
Need help arranging accommodations for a range of site visits, understanding when they can visit sites to work with staff	**Researchers, Students**

Appendix B: Co-Created Group Pitches on Value Proposition:

1. **Group 1 - CA-SSN field methods and data collection personnel:** Imagine your audience as your neighbor rancher. They care for the land but don't know about 30X30. They want to protect, steward, and sustain the land. CA-SSN is helping steer government and local stakeholder action to protect and restore land. CA-SSN will monitor what we have and what we are losing. Sentinel Sites for Nature uses technology to monitor at a scale and frequency never done before. This will save the world.

2. **Group 2 - Research scientists:** Biodiversity is changing in a way that will have negative impacts on human and ecosystem health. We need data across the state of California to evaluate and make decisions in response to changing biodiversity. Sentinel Sites for Nature will provide that data with a consistent methodology and in a sustainable manner. This data can be used by managers, by scientists, and by policy makers, to inform conservation actions and as an early detection for ecological change. On top of that, this will serve as a template for other states and countries to adopt these monitoring measures.

3. **Group 3 - Innovators in sensing, analytics, and AI:** We are currently facing an existential crisis in the biodiversity world. We have huge amounts of data, but it isn't informing decisions around conservation of biodiversity. What do we do with all of this data? How do we make sure that it actually informs conservation on the ground? Sentinel Sites for Nature can provide the opportunity to consistently monitor biodiversity and establish protocols and templates for all of that data to inform biodiversity conservation and well being on the land. With this template, best practices, and understandings, we can make California a leader in biodiversity and conservation.

4. **Group 4 - Management and policy community - California:** Imagine a tool that will show the pulse of nature and the environment in real time in a way that will help us understand and preserve natural resources for the benefit of California lives and livelihoods for generations to come. Similar to existing apps like google maps, we will use CA-SSN to bring together data from across the state to create a reliable trustworthy scalable data framework network and source. This source will combine technology in a way that will present the data to the community so that we can improve our lives and show the world that we can be leaders in biodiversity management.

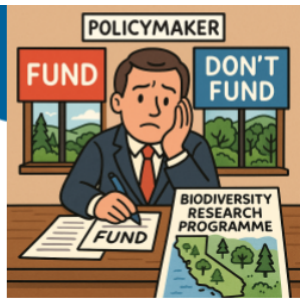
5. **Group 5 - Management and policy community - Outside California:** Imagine general tax payers as the audience. Just as we track our health with a watch, keep our car running with diagnostics– we can do the same for the environment. Sentinel Sites for Nature will provide a trustworthy and collaborative approach to tracking those baseline information pieces that we will need to provide information about how to keep our systems running and understand trends and when they are not running.

Appendix C: Day 3 Slides from Each Groups Presentations

Group 1 - Standardized field and data methods

Policy maker

Goal: Decide whether or not to fund for the next 2 years

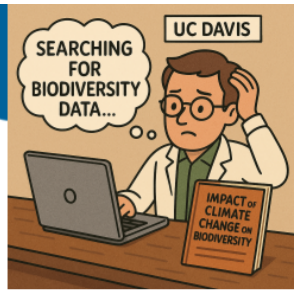


Actions

1) *Learn about the program*
   - Solution: Visit the website for an easy to follow overview
2) *Deepen their understanding and ask questions*
   - Solution: Get a presentation/pitch from someone [Gary]
   - Solution: SSN has a clear communication plan for funders/policymakers
3) *Need a way to evaluate if it is worth continuing investment*
   - Solution: SSN develops an impact report and business case

Researcher

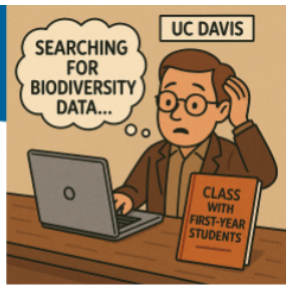
Goal: Data to analyse biodiversity patterns in California



Actions

1) *Find the data*
   - Solution: A good website and visibility e.g. through conference presentations
2) *Understand if the data is fit for purpose*
   - Solution: Get a preview of the data, and clear metadata
   - Solution: Link to publications/reports describing data and power analyses
3) *Easy way to download and analyse data*
   - Solution: Simple download instructions and R tutorials, linked datasets
   - Solution: Clear citation requirements

Lecturer



Goal: Data to support a biodiversity module on an undergraduate programme

Actions

1) *Find the data*
   - Solution: A good website and visibility e.g. through conference presentations
2) *Easy access to students*
   - Solution: Vignette that describes how the data can be retrieved and analysed in R
   - Solution: Suggested slide deck for a class based around the SSN data
   - Solution: An education and outreach role within the network (or link up with existing educators)

Restoration Manager

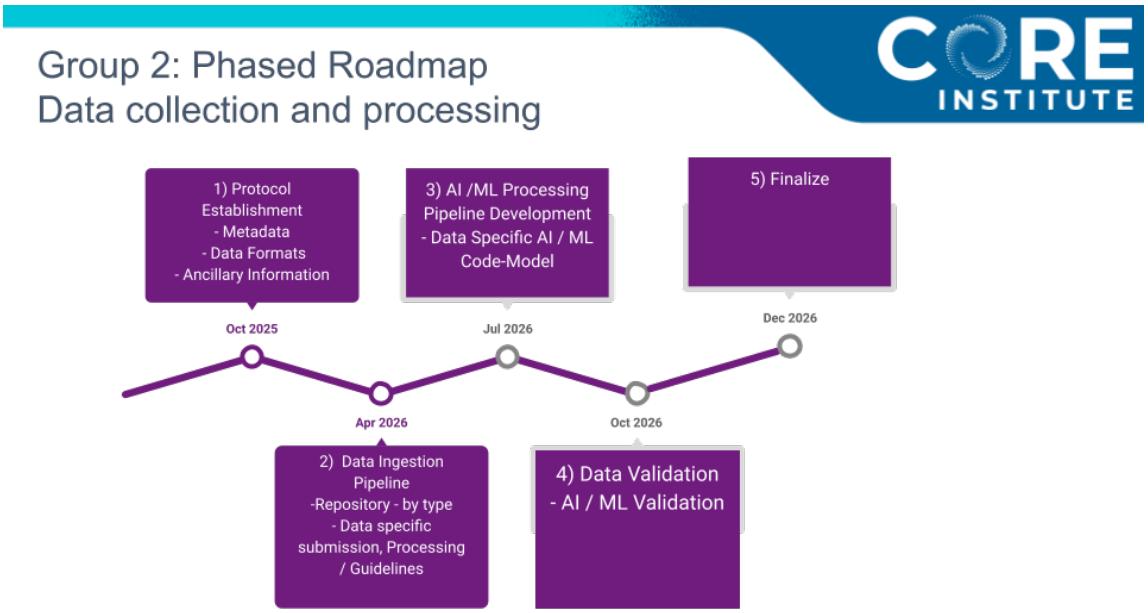


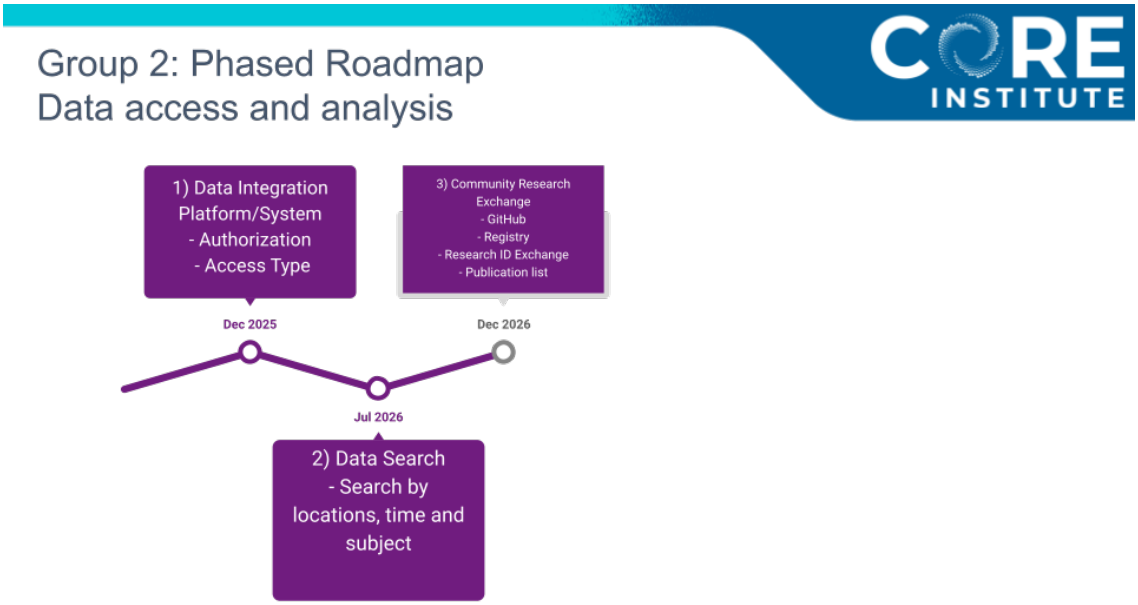
Goal: Replicate SSN protocols in order to assess the effectiveness of restoration

Actions

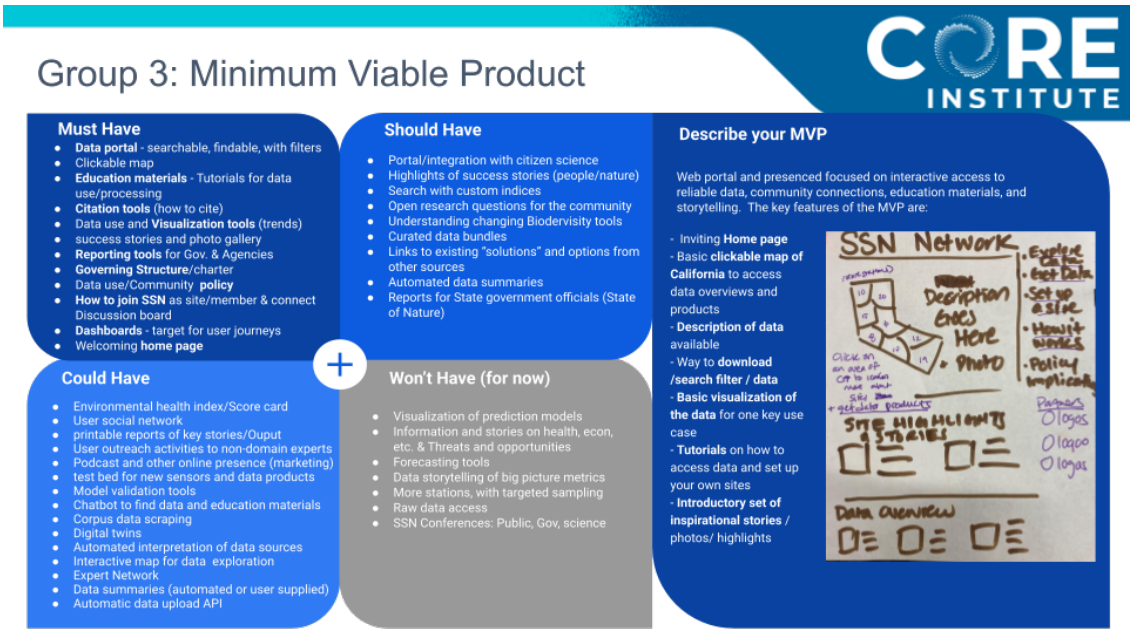
1) *Implement management that is site specific, and impact on protocols*
   - Solution: Guidance / case studies on how to do this
2) *Understand how long to monitor for*
   - Solution: Refer publications and reports on efficacy and power, strengths and limitations
   - Solution: Point of contact for guidance, drawing on SSN experience

Group 2 - **Data pipelines processing, & products**





Group 3 - **Data accessibility, analytics & use platforms**


Group 3: Minimum Viable Product
CORE INSTITUTE
Must Have
Data portal - searchable, findable, with filters
Clickable map
Education materials - Tutorials for data use/processing
Citation tools (how to cite)
Data use and Visualization tools (trends)
success stories and photo gallery
Reporting tools for Gov. & Agencies
Governing Structure/charter
Data use/Community policy
How to join SSN as site/member & connect Discussion board
Dashboards - target for user journeys
Welcoming home page
Should Have
Portal/integration with citizen science
Highlights of success stories (people/nature)
Search with custom indices
Open research questions for the community
Understanding changing Biodervisity tools
Curated data bundles
Links to existing "solutions" and options from other sources
Automated data summaries
Reports for State government officials (State of Nature)
Could Have
Environmental health index/Score card
User social network
printable reports of key stories/Ouput
User outreach activities to non-domain experts
Podcast and other online presence (marketing)
test bed for new sensors and data products
Model validation tools
Chatbot to find data and education materials
Corpus data scraping
Digital twins
Automated interpretation of data sources
Interactive map for data exploration
Expert Network
Data summaries (automated or user supplied)
Automatic data upload API
Won't Have (for now)
Visualization of prediction models
Information and stories on health, econ, etc. & Threats and opportunities
Forecasting tools
Data storytelling of big picture metrics
More stations, with targeted sampling
Raw data access
SSN Conferences: Public, Gov, science
Describe your MVP
Web portal and presenced focused on interactive access to reliable data, community connections, education materials, and storytelling. The key features of the MVP are:
- Inviting Home page
- Basic clickable map of California to access data overviews and products
- Description of data available
- Way to download /search filter / data
- Basic visualization of the data for one key use case
- Tutorials on how to access data and set up your own sites
- Introductory set of inspirational stories / photos/ highlights
SSN Network
Description Goes Here
Photo
Data overview