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NEON BIOARCHIVE: CONCEPT OF OPERATIONS

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1 DESCRIPTION

1.1 Purpose

The purpose of this document is to summarize the concept of operations of the NEON Bioarchive. Major elements of the bioarchive include the coordination of sample shipping and the design of standardized protocols across participating facilities.

1.2 Scope

This document applies to all samples collected by the NEON Project at terrestrial and aquatic sites during the 30-year life cycle of the observatory. This includes those associated with the Aquatic Observations System (AOS), Terrestrial Observation System (TOS), and Terrestrial Instrument System (TIS).

1.3 Applicable Documents

AD [01]	NEON.DOC.000001	NEON Observatory Design
AD [02]	NEON.DOC.002652	NEON Level 1, Level 2, and Level 3 Data Products Catalog

1.4 Reference Documents

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	NEON.DOC.000027	NEON Sample Use Policy
RD [04]	NEON.DOC.000019	NEON Data Use Policy

1.5 Acronyms

COTS	Commercial-off-the-shelf
DOI	Digital Object Identifier
GBIF	Global Biodiversity Information Facility
TDWG	Taxonomic Databases Working Group

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2 NEON BIOARCHIVE FACILITY

2.1 Overview

A key feature of NEON’s science design is to establish a “...curated collection of organisms, key body parts of organisms, and substrates... open to researchers for analysis, both now and in the future as new technologies emerge.” [AD [01], p. 31]. What we now call the NEON Bioarchive encompasses aquatic and terrestrial samples and specimens (collectively called samples below) collected during annual sampling at NEON sites – i.e. voucher specimens, whole organisms, tissues, and samples processed for chemistry, disease and genetics. It includes shipping, handling, preservation, storage, and distribution of samples.

The overarching goal of the NEON Bioarchive is to make reference material and replicate samples available to the science and education communities for future research and retrospective studies. The collected samples provide a rich resource for future research efforts, enabling scientists to identify organisms, analyze archived blood and tissue samples for viruses and other pathogens, and perform new isotopic, biogeochemical and microbial analyses on water and soil samples.

The bioarchive will be unique among natural history collections as a result of its diversity of sample types collected consistently across spatial and temporal scales. It is intended to provide a record of samples of known provenance linked to contextual meta-data that can be repeatedly used for verification of field observations, archived for new studies, and the application of new analytical techniques and technologies. Samples will be stored in replicate and in a manner that protects against major loss in the event of a catastrophe and allows for destructive analysis.

2.2 Functional Design Features

The NEON Bioarchive may be single institution or consortium of collaborating facilities. A summary of the major design features follows:

1. The NEON Bioarchive shall have the capacity to:
 - a. Accommodate >70,000 samples per year for no less than 5 years and up to 30 years
 - b. Grow as samples accumulate over time
 - c. Handle a wide variety of sample types and storage conditions (see Appendix A).
2. The NEON Bioarchive shall be:
 - a. Designed for efficiency and utility – incorporate systems engineering principles
 - b. Responsive to needs of external researchers, including the ecological and collections communities
 - c. Discoverable with meta-data access; planned to be an extension of NEON’s existing API allowing searches, e.g., based on geolocations. (A central Fulcrum Application is being developed for sample management and shipping.)
 - d. Capable of efficient and timely sample processing – e.g., accessioned within one month of receipt

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3. The NEON Bioarchive shall:

- a. Curate samples in conformance with accepted best practices, such as those being compiled by the Society for the Preservation of Natural History Collections (SPNHC) --
<https://spnhc.biowikifarm.net/wiki>
- b. Store samples in perpetuity – at least a 30-year time horizon
- c. Maintain emergency and disaster plans to mitigate risks to the bioarchive
- d. Make samples readily available for loan in a timely manner (i.e., within 6 months after received)
- e. Accommodate destructive and non-destructive uses
- f. Reserve a portion of individual samples for non-destructive uses

NEON samples may be held separately from the repository's general collections, or they may be incorporated into general collections depending upon which is deemed by mutual agreement to be most cost effective and efficient in making material available to the scientific community.

2.3 Technical and Operating Requirements

Collectively, the bioarchive shall have the ability to curate all NEON samples in accordance with the sample specific requirements listed in Appendix A. Specific operating requirements follow below. These may be subject to further discussions with the participating institutions to ensure cost effective and efficient operations and to enhance the observatory's impact on ecology at the continental scale. Specific terms and conditions will be mutually agreed upon by the NEON Project and participating institutions.

1. *Accessioning*: Ninety (90) percent of samples received shall be accessioned within 10 business days of receipt. Ownership of samples shall transfer to the bioarchive upon accessioning subject to clearly articulated and mutually agreed upon rights, roles and responsibilities.
2. *Sorting and Identification*: Where practical, specimens will have been sorted by taxonomic group, preferably at the rank of taxonomic Order or below, prior to delivery to the bioarchive. Prepared specimens will have been labelled. All preserved material will have been prepared in accordance with best practice applicable to the taxon/material being preserved.
3. *Archives*: Labeled samples shall be received, preserved, archived and curated by the bioarchive institution(s) following standard/best practices. NEON will transfer ownership of samples to the archive facility – except in cases where prohibited by land owners (e.g., National Park Service). This information will be communicated to the selected institution(s) by NEON as these samples are generated.
4. *Unique Identifiers*: NEON requires that all NEON-collected samples contain a NEON unique identifier, which will be attached to the sample and communicated to the bioarchive at the time the new sample is received. Institutional identifiers (preferably globally unique identifiers [GUID]) are also highly encouraged in addition to the required NEON identifier. NEON will

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need to receive any such institution identifiers as it intends to track all of these identifiers as part of the sample metadata.

5. *Cataloguing*: Cataloguing is expected to follow the best standards and practices and as mutually agreed upon with the NEON Project. It may not be necessary to hold all NEON collections separately from the repository's general collection; but they do need to be catalogued such that they can be easily identified and retrieved as NEON samples.
6. *Loans*: NEON-generated samples shall be made available for use by and loan to NEON and external investigators within a reasonable period of time of delivery of samples and metadata by NEON to the bioarchive – 90% of loan requests should be fulfilled within 4 weeks. Loan and use of NEON samples shall be in accordance with NEON's Sample Use Policy (RD [03]) and with the collections community's standard policies and procedures unless otherwise mutually agreed upon. Each loan may be assigned a DOI by the Bioarchive to facilitate tracking use of samples. A GUID might suffice if the ID is meant for machine (software) consumption. One might also want a human readable Loan ID, which could just be an integer if one is needed for referencing loans in correspondence like overdue letters, etc.
7. *Destructive Sampling*: The repository shall formulate destructive sampling policies in consultation with the NEON Project. Consultation with NEON is expected when a proposed research use requires consumption of >50% of a sample, and where the same NEON samples are requested by more than one researcher at a given time. These types of requests will require consultation with NEON before being processed. The NEON Bioarchive shall encourage research use while maintaining a critical set of samples for a "forever archive," defined as appropriate for each sample type.
8. *Deaccession*: All deaccession or permanent transfer of samples of NEON generated samples must be coordinated with NEON and approved in writing.
9. *Sample Data Availability*: Sample metadata provided by NEON may be made available on the bioarchive web site(s). In addition, NEON will coordinate with the bioarchive to provide data to external data aggregators (e.g., GBIF) as appropriate.
10. *Permitting*: NEON will provide copies of all collecting and salvage permits relating to the samples to be transferred to the bioarchive, including incidental vertebrate and invertebrate by-catch mortalities, as needed. Some NEON collection permits (current or future) may specify where certain taxa (e.g., rare species) will be deposited. In the event that a sample needs to be transferred to another institution, NEON will inform the bioarchive and agrees to coordinate these activities and incur the costs associated with this transfer.
11. *Reporting*: The NEON Bioarchive shall submit an annual report that summarizes use and disposition of NEON samples. It shall also include any updates to data that result from study of the collections, such as revisions or corrections to sample identifications. The bioarchive shall maintain careful records of the samples available and their use. NEON will work with the Bioarchive to implement means to assess and track scientific impact of the bioarchive.

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12. *Timing of Samples:* Samples will be shipped from NEON's Domain Support Facilities, Headquarters or intermediate analytical facilities to the bioarchive facility at varying times throughout the year. An estimate of the numbers of samples to be collected and delivered to the bioarchive each year is presented in Appendix A.
13. *Emergency Plan:* The NEON Bioarchive is required to prepare and, execute if needed, an emergency plan to safeguard the integrity of the samples in case of severe weather or other natural disasters, fire, floods, etc.
14. *Agreements:* Agreements are expected to be of long-duration i.e., 5 or more years, but may be subject to periodic reviews. Agreements will state terms and conditions related to potential commercial applications.

2.4 Information Management

The NEON Bioarchive shall implement a data management system, subject to NEON approval, that is consistent across the bioarchive – whether a single institution or a consortium of several facilities. Commercial-off-the-shelf systems (COTS) are available, such as *Specify*, *Arctos*, *Symbiota*, etc. Adoption of a single database is necessary to ensure efficiency and quality control, and to provide a clear audit trail. Use of multiple systems will greatly increase costs and information management complexity.

The NEON Bioarchive is expected to partner with other bioinformatics databases to increase the user awareness of the samples and data available. Use of existing standards and schema will facilitate the use of data across sites and within sites, and with non-NEON data sets. For example, the bioarchive shall take advantage of existing standards such as those maintained by the Taxonomic Databases Working Group (TDWG), which is the standards-setting arm of the Global Biodiversity Information Facility (GBIF).

Cataloging and data basing shall follow best practices of the collections community and as mutually agreed upon by NEON and the bioarchive. Our intent is to use a database schema that incorporates data concepts already established and in use by the collections and specific scientific communities. An interface with a sample management system (chain of custody) is needed to ensure a documented lineage from, e.g., whole organisms, tissues, and DNA extracts.

2.5 Data Products

NEON will make sample metadata available via the NEON Data Portal such as sample type, species name and sex, NEON unique identifiers, identifiers assigned to samples by the bioarchive or intermediate analytical labs, locality information, collection dates, and other information to be agreed upon. These metadata will be discoverable through the portal and will link samples to their respective observational and measurement data.

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2.6 Roles and Responsibilities

Collections and Laboratory Analysis Team (CLA): The NEON Bioarchive is supported by CLA, a core group of science and technology staff members with expertise and experience in program management (i.e., preparation, management and monitoring of contract scopes [e.g., statements of work]) and coordination with private and public procurement and acquisition services). This team carries out varied operational tasks, which includes, but is not limited to, communications, and coordination of sample inventory and shipping.

The CLA team plays the key role in bringing together several key elements of the organization to ensure success of this complex and important Observatory activity.

- **Science Operations:** Subject matter experts prepare science-based technical specifications, and they assist in evaluating requests for destructive use or consumption of >50% of a given sample.
- **Field Operations:** Domain field staff are responsible for collecting, processing and shipping of samples. In some cases samples are first sent to a laboratory facility for analysis prior to being shipped to the archive.
- **Data Services:** Maintains observatory sample chain of custody system functionality – i.e., until the sample is deposited in the bioarchive. Information on the disposition of samples will be accessible via the data portal. However, once accessioned into the bioarchive, samples will be tracked and reported on by the bioarchive.
- **Calibration and Validation Laboratory:** Review annual quality assurance (QA) and quality control (QC) reports provided by the bioarchive.
- **Procurement:** prepare agreements in accordance with all applicable laws and federal acquisition regulation.

NEON Bioarchive Advisory Group: An external advisory group will be established to provide input, recommendations, audits, and periodic review of the NEON Bioarchive. Reviews will be conducted periodically to evaluate how well the bioarchive is meeting its goals. The group will also assist in addressing areas of conflict such as competing and large requests.

Users of the NEON Bioarchive are:

- Responsible for requesting and appropriately managing samples from the Bioarchive, including complying with terms of any award or grant funding research or other use of the samples and with applicable laws and regulations, and return of the samples to the bioarchive if the samples were provided as a loan (as opposed to destructive use or a gift to be archived in another permanent repository such as a museum collection).
- Responsible for reporting use of samples and data to the bioarchive and/or directly to NEON including use in scientific reports, publications, theses, dissertations, and classroom or other educational use. The DOI attached to each loan or gift of samples or data from the Bioarchive must be used when reporting data use.

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2.7 Implementation Plan

Task #	Task	Description	Due Date
1	NEON Bioarchive IPT	Explore/recommend a course of action to achieve a “best value” approach to the NEON Bioarchive.	03/30/2017
2	Bioarchive Con Ops	Update concept of operations for the NEON Bioarchive	On-going
3	External Expertise	Solicit/receive input from external expertise regarding issues and priorities	05/15/2017
4	Workshop	Workshop including the NEON Bioarchive IPT, key external proponents, and NSF PO to review proposed alternatives.	05/15/2017
5	Solicit Design Proposals	Solicit initial design and rough order of magnitude costs for alternatives	05/22/2017
6	Alternatives Analysis	NEON IPT completes cost-benefit assessment and recommendations as to which alternative to pursue.	06/19/2017
7	Recommendations	Submit recommendations to NEON PMO	06/30/2017

2.8 Risks and Issues

- A single standalone archive may pose a higher risk than a distributed network due to having all archived material in one geographic location and lacking back-up facilities to handle sample overflows.
- Individual collection facilities may be reluctant to accept large amounts of bulk samples that are seen as potentially less valuable to the collections community. Some, such as bulk soil samples, are nontraditional for most collection-holding institutions – though of considerable interest to ecologists.
- Individual facilities may become reluctant to accept duplicate material over a long period of time. While replicate samples are expected to be of value to the ecological community, sample duplications may be seen as less valuable for reference collections.
- Individual facilities may be unable to make samples available in a timely manner due to the quantity of material delivered.
- Individual facilities may propose to house samples with which they have limited experience.

2.9 Quality Assurance and Quality Control

As part of the proposal evaluation process, proposing institutions will be qualified on the basis of available documentation and certifications along with site visits. Examples of the types of documents that should be made available include the following:

1. Plans, Policies and Procedures
 - a. Collections Emergency Response and Recovery Plan
 - b. Emergency Operations Plan
 - c. Integrated Pest Management Plan
 - d. Security plan

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- e. Long-range Conservation Plan
- f. Data Management Plan and Backup Policy
- g. Collections Management Policy
- h. Destructive Sampling Policy
- i. Accession and Deaccession Policies and Procedures
- j. Collection Procedural Manuals
- k. Loan Agreements and Conditions
2. Institutional Permits (USFWS, USDA APHIS, CITES)
3. Database Documentation Standards
4. Facility Report
5. Website and evidence of participation in VertNet, iDigBio, and GBIF
6. Loans and accession files and databases

Annual QA/QC reports shall be furnished by the bioarchive based on criteria mutually agreed upon by the participating institutions and the NEON Project.

A NEON Bioarchive Advisory Group will conduct periodic reviews to evaluate how well the bioarchive is meeting its goals.

APPENDIX A. Estimated annual number of NEON samples and specimens

Tower Samples		#/site	## Sites	#/Year	Storage Condition	Storage Container
TIS	Wet Deposition	26	43	1,118	-4°C	0.5-1L jar
TIS	Dry Deposition	26	6	156	dry	Filter (8"x10")
	TIS Subtotal			1,274		

Terrestrial Samples		#/site	## Sites	#/Year	Storage Condition	Storage Container
TOS	Ground beetle pinned/pointed	200	47	9400	dry	Unit trays
TOS	Soil	190	47	8930	Ultralow	2oz. Whirlpaks
TOS	Small mammal ear punch	108	47	5076	Ultralow	2 mL cryovial
TOS	Small mammal fecal sample	108	47	5,076	Ultralow	2 mL cryovial
TOS	DNA extractions--Soil	96	47	4,512	Ultralow	96-well plate or 2 mL cryovial
TOS	DNA Extractions--Beetle	96	47	4,512	Ultralow	96-well plate or 2 mL cryovial
TOS	Ground beetle by-catch in bulk	83	47	3,901	ETOH	50mL Falcon tubes
TOS	Mosquitos Bulk	74	47	3,478	Ultralow	2-15mL cryovial
TOS	Mosquitoes pinned/pointed	68	47	3,196	dry	Unit trays
TOS	Ticks	63	47	2,961	ETOH	2mL vial
TOS	Small mammal blood	60	47	2,820	Ultralow	2 mL cryovial
TOS	Ground beetle pooled	52	47	2,444	ETOH	50mL Falcon tubes
TOS	Small mammal hairs/whiskers	44	47	2,068	dry	Archival coin envelope
TOS	Disease--Mosquito pools	96	20	1,920	Ultralow	96-well plate or 2 mL cryovial
TOS	DNA Extractions--Mosquito	96	20	1,920	Ultralow	96-well plate or 2 mL cryovial
TOS	DNA Extraction-Smammals	96	20	1,920	Ultralow	96-well plate or 2 mL cryovial
TOS	Plant voucher specimens	20	47	940	dry	Individual mounts
TOS	Small mammal specimens	20	47	940	dry	Individual mounts
TOS	Plant (biomass)	50	8	400	dry	20mL vial
TOS	Soil (every 5-10 yrs) Air dried	45	8	360	dry	250mL jar
TOS	Plant belowground (biomass)	20	16	320	Ultralow	20mL vial
TOS	Disease--Tick pools	3	47	141	Ultralow	96-well plate or 2 mL cryovial
TOS	Leaf litter	15	8	120	dry	20mL vial
	TOS Subtotal			67,355		

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Aquatic Samples		#/site	## Sites	#/Year	Storage Condition	Storage Container
AOS	Algae: Periphyton, seston, phytoplankton – diatoms	27	34	918	Freeze dried	Vials
AOS	Algae: Periphyton, seston, phytoplankton – diatoms	27	34	918	dry	Glass slides
AOS	Algae: Periphyton, seston, phytoplankton – soft algae	27		918	glutaraldehyde	60 mL jar or smaller
AOS	Macroalgae	15	34	510	glutaraldehyde	60mL jar
AOS	Aquatic macrophyte vouchers	15	34	510	dry	Herbarium paper
AOS	Aquatic mosses/lichens/liverworts	15	34	510	dry	Herbarium packet
AOS	Macroinvertebrate specimens	24	34	816	ETOH	500mL jar or smaller
AOS	Zooplankton specimens	9	8	63	ETOH	500mL jar or smaller
AOS	Fish voucher specimens	30	34	1,020	ETOH	Individual/lot
AOS	Fish tissue	50	34	1,700	ETOH	2-10mL vial
AOS	Macroinvertebrate homogenates	9	34	306	Ultralow/ETOH	2mL cryovial
AOS	Zooplankton homogenates	9	7	63	Ultralow/ETOH	2mL cryovial
AOS	Aquatic Microbes--Benthic	24	24	576	Ultralow	Cryovial or Sterivex filters
AOS	Aquatic Microbes --Water	18	34	612	Ultralow	Sterivex filters
	Aquatic Subtotal			9,377		
Grand Total				78,006		