

A Long-form Research Program in Human Behavior, Ecology, and Culture

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Objective

Human societies display long-form adaptation. Humans adapt behaviorally, and human behavior requires years to acquire and generations to develop. Long-form behavioral adaptations explain our species' extraordinary diversity and its ecological success. At the same time, the cognitive mechanisms and population dynamics that make long-form adaptation possible also make possible evolutionarily novel societies and forms of behavior and technology. Humans have co-existed with these evolutionary novelties for long enough that our genes are adapted to them.

The study of long-form adaptation will benefit from long-form research that is both longitudinal and comparative, allowing it to inform theories of human evolution and the dynamics of human societies. Normal human science lacks the necessary infrastructure. This document presents a sketch of a research program.

The major goal is to develop a coordinated and longitudinal, but relatively decentralized, field research network. This network takes its empirical direction from current theories of human adaptation. But it is primarily an infrastructure project that would improve our ability to study the microevolution of human behavior and culture in ecological context.

The goal is absolutely not to create a completely standardized, top-down cross-cultural project. Rather, the network would support and facilitate long-term studies as elected by individual researchers, making use of practical and ethnographic expertise at each site and encouraging innovations to flow in all directions. Topics of research would overlap, both because of the synergies arising from overlap and because of shared interests in the roles of behavior in human adaptation and evolution. This document presents suggestions along these lines, painting an image of topical coverage that is much more complete for any one field site than would normally be practical or desired by any individual investigator.

While the overall goal is long-term progress and accumulation of explanatory power, incremental tests and discoveries are ensured by any rigorous and carefully theorized field project, undertaken at any length of time.

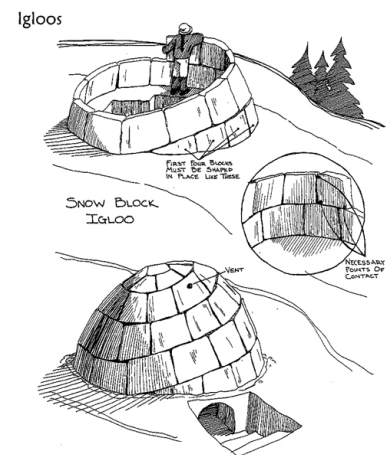


Figure 1: The design of an igloo is non-obvious and highly adaptive. It takes decades for an individual to grow and learn enough to build one, and it took generations for the design to evolve. The developmental, cultural, and evolutionary dynamics that produce commonplace wonders like the igloo remain poorly understood. However, human societies in all regions depend upon material and immaterial products of this kind.

Contents

<i>Objective</i>	1
<i>Integrated Approach</i>	3
<i>Getting Specific: Processes, Measures, and Models</i>	5
<i>Data Curation and Analysis</i>	10
<i>Orderly Chaos of a Research Network</i>	13

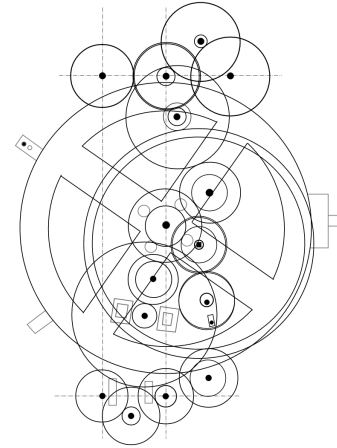


Figure 2: Schematic of the Antikythera mechanism, an analog computer from *circa* 200 BC. The cognitive and population process that generate igloos also generate artifacts like this, as well as the societies that foster them.

Integrated Approach

The human species adapts through a population-level process of behavioral evolution. Explaining the origins and design of this process demands study of the integration of human life history, cognition, and behavior in ecological and social context. Comparative and longitudinal fieldwork has a special role to play. Equally important is the development and application of dynamic, quantitative models of human cognition, behavior, and population dynamics.

Human adaptation depends upon COMPLEX SKILLS, PROLONGED DEVELOPMENT, and FLEXIBLE PRO-SOCIALITY. Human life history and sociality weave together socially-transmitted skills that are more complex than any organism could invent in its lifetime.¹ The acquisition of these complex skills depends upon the existence of a long juvenile period during which to observe, practice, and improve. The maintenance of a long juvenile period depends upon the inter-generational sharing of the economic surplus and cultural information it engenders. The style of human adaptation binds together real behavioral evolution with slow growth and intense interdependency.² Simultaneously, it has made possible new kinds of societies and patterns of behavior which are equally complex and beyond the capacity of individuals to invent.³

In this document, I refer to the major adaptive style of humans as LONG-FORM ADAPTATION. Human individuals require long developmental periods to acquire behavior, and this behavior itself takes generations to develop. Humans, like all animals, have other modes of adaptation. But the ecological success of our species owes to the ways that our slow life history and social cognition engender inter-generational processes that create locally adaptive behavior, technology, and social institutions. I avoid the word “culture” only because no one agrees on its meaning or implications. But many of the differences commonly described as cultural are products of these processes.

In general terms, none of this is controversial within evolutionary anthropology. There is broad agreement about the importance of behavioral transmission and evolution in our species. But specific theories of the evolution of the human species must confront the integrated nature of human physiology, life history, cognition, and sociality. Doing so is currently difficult. Most research on human behavioral dynamics is constrained to dis-integrated measurement, short-term experimentation, and cross-sectional observation. What form should a research program take instead, in order to address this integration, test alternative models, and constrain and inspire future theorizing?

THE RESEARCH PROGRAM SHOULD BE COMPARATIVE, since human adaptation varies greatly with ecological and social context. No single ecological context, scale of social organization, or mode of econ-

¹ J. Henrich and R. McElreath. The evolution of cultural evolution. *Evolutionary Anthropology*, 12:123–135, 2003

² H. Kaplan, K. Hill, J. Lancaster, and A. M. Hurtado. A theory of human life history evolution: Diet, intelligence, and longevity. *Evolutionary Anthropology*, 9(4):156–185, 2000

³ P. J. Richerson and R. Boyd. *Not by genes alone: How culture transformed human evolution*. University of Chicago Press, 2005; and J. Henrich. *The Secret of Our Success: How Culture is Driving Human Evolution, Domesticating Our Species, and Making Us Smarter*. Princeton University Press, 2016

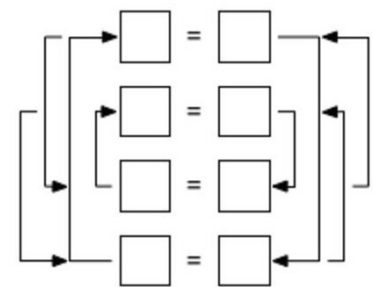


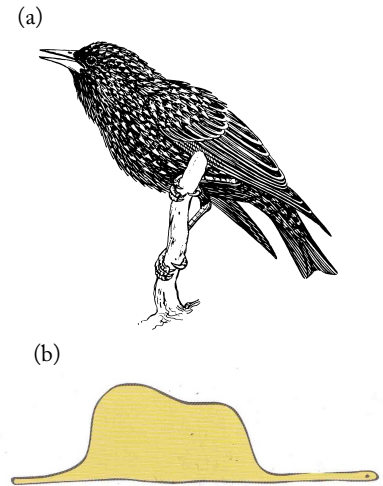
Figure 3: As an example of the complexity of human societies, kinship systems often have complex internal logic. Above: Lardil subsections place individuals in one of 8 categories. Rows are marriageable pairs of categories. Columns are categories belonging to the same *matri-cycle* by which descendants are assigned category membership. From: Hale, K. 1997. Lardil dictionary. Gununa, QLD: Mornington Shire Council.

omy is sufficient. Contemporary foragers are important, since foraging remains the original human career. But modern foragers are not fossils. They are derived and constrained to a limited range of ecological contexts and forms of social organization. Industrial and agricultural societies reflect human nature as well as any foraging society, contemporary or prehistoric. Transformations among economies and social structures are perhaps even more informative.

IT SHOULD BE LONGITUDINAL, since the dynamics of human life history and culture play out over years and decades. Cross-sectional studies suffer from both poor explanatory power and the confounding of individual variation with age and cohort variation. Cross-cultural research with shallow time depth suffers greatly in this way. Experiments are attractive alternatives in many fields. But usually controlled experimentation in this subject is neither practical nor ethical. Even when practical, experiments too often achieve their explanatory power at the cost of relevance. At their worst, they encourage scientists to waste time theorizing what happens in experiments instead of what happens in societies. Longitudinal studies complement other approaches and provide a picture of the empirical target that all approaches must eventually explain. Such studies commit us to substantial costs in time, resources, and analysis. These costs are justified by the ability to investigate long-form adaptation at the pace that it develops.

IT SHOULD BE INTEGRATIVE, in the sense that it integrates the biology of human development and cognition with the dynamics of behavior and culture. Human societies are *interactionally complex*⁴: They are not so easy to understand in pieces, because the pieces possess strong causal interactions. Kidneys can be understood as functionally discrete from other parts of the body, but human families cannot be well understood as functionally discrete from society. This is not an argument against reductionism. Rather it is an argument for how to use reductionism, in pursuit of causally mature models of complex systems.

Successful empirical integration depends upon analytical integration. We embrace Ronald Fisher's advice about causal inference in observational settings: *Make your theories elaborate*.⁵ Theory should represent and data should inform dynamic, state-based models of developmental and behavioral change. Such an approach stands in contrast to the usual practice of fitting generalized linear models that do little more than produce static descriptions of samples. We return to and elaborate on this point in a later section (page 10).



Mon dessin ne représentait pas un chapeau. Il représentait un serpent boa qui digérait un éléphant

Figure 4: Life history, social exchange, and cognition are inherently linked in adaptation: Two illustrations. (a) The Starling is long lived, but unlike humans it grows quickly. It has no opportunity to acquire complex skills before it must fend for itself. (b) The boa constrictor grows slowly, but it has neither need nor ability to share its surplus. Both the boa and the starling fail to leverage adult surplus into a catalyst for the next generation to develop further surplus.

⁴ W. C. Wimsatt. Complexity and organization. In K. Schaffner and R. S. Cohen, editors, *PSA 1972*, pages 67–86. Philosophy of Science Association, 1974

⁵ W. G. Cochran and S. P. Chambers. The planning of observational studies of human populations. *Journal of the Royal Statistical Society A*, 128(2):234–266, 1965

Getting Specific: Processes, Measures, and Models

The conduct of research needs clear questions embodied by clear models informed by relevant measurements that are derived from theorized biological processes. At the same time, an effective infrastructure should support the equally important discovery role of empirical research.

Scientific infrastructure needs theory to inform its design. There are too many things to measure, and too many ways to operationalize these things, for generalized empiricism to pay off. At the same time, good infrastructure has use beyond any narrow original purpose. Consider the Hubble Space Telescope (at right), which was motivated in part by cosmological questions that could not be addressed with Earth-based telescopes. It nevertheless produced the best images of more traditional subjects. This was fortunate, because at the time of deployment, its primary mirror had the wrong shape. Until the optics were replaced, the telescope could not function as intended. Despite this serious flaw, the telescope was still better than any ground-based telescope up to that point, and computational strategies made it possible for it to address even some of the original cosmological questions. The Hubble was an infrastructure project that succeeded despite failing.

The proposal here is also an infrastructure project. To address contemporary, theoretically-motivated questions about human behavior, human cultural dynamics, and their evolutionary origins, ordinary scientific instrumentation is insufficient. Cross-sectional studies that neglect the diversity and interactional complexity of human societies are often all that is possible. But such studies also struggle to address general questions about the functional integration and evolution of human life history, cognition, and long-form adaptation. Better instrumentation requires an initial theoretical focus that guides its design. Inevitably, the instrument will be imperfect at the start. But it can still be better than any conventional instrument to date.

The tables on the next page two pages sketch the connections between theoretically motivated questions about long-form adaptation, measurements that can be made in the field, and model-based inference. There are three general domains of inquiry (for example):

1. How is behavior acquired, and how does learning generate population dynamics of behavior and technology?
2. How is energy produced, traded, and invested?
3. How does the demographic structure of the population, and therefore the life history of our species, interact with both learning and production?

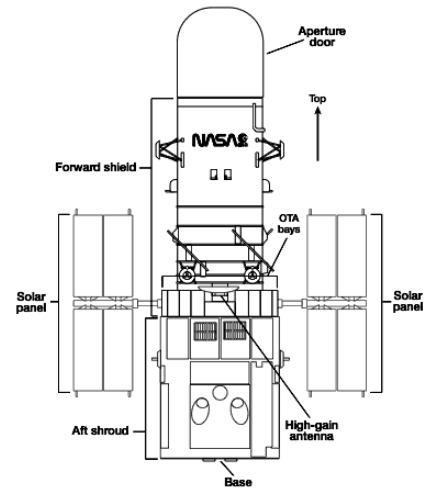


Figure 5: The Hubble Space Telescope was designed for specific questions, but also supports general discovery. It was also notably broken at time of deployment.

TABLE 1. Connections among domains of investigation, theoretical processes of long-form adaptation, operational measures, and inferential model structures.

Domain	Processes (for example)		Measures (for example)		Models (for example)
<i>How is behavior acquired? How do behavior and technology evolve?</i>	Learning strategies, age and state conditional Interaction and relationship formation strategies	→	Association matrices, social networks, trait distributions, status, reputation, social attitudes	→	Probability of trait change, conditional on strategy, experience, associations, and traits
<i>How is energy produced, traded, and invested?</i>	Wealth, income, exchange, investment, and cooperation	→	Consumption, income, wealth, inheritance, gifts, exchange networks, labor networks, norms, technology impacts, domesticated plants and animals, land and resource use/impacts	→	State-dependent productivity, cooperation and reciprocity; relationships of skill and knowledge with technology and production
<i>How does the stock and composition of the population change and influence behavior and learning?</i>	Fertility, development, mortality, growth, health, kinship, structure, migration	→	Demography and historical demography; Biomarkers of growth, health, and aging	→	State-dependent vitality and renewal, state-dependent skill and behavior

TABLE 2. Example hierarchy of operational measures, by domain.

Level	Behavior	Production	Demography
Level ZERO (0) foundational easy to comparably define easy to collect	voice & dialect time allocation (reported) domain knowledge skill/knowledge (reported) social networks/fields	income (household report) wealth (household report) exchange relationships (re- ported) inheritance (reported)	height weight grip strength genealogy household composition migration history
Level ONE (1) high value site-unique definitions more time consuming	time allocation (measured) behavioral experiments skill/knowledge experiments material culture (3D scans)	income (individual measure) wealth (individual measure) social accounting matrices (household) exchange (measured) inheritance (measured)	[biomarkers req. blood spots or buccal cells] telomere length immune assay endocrine assay RNA expression glycosylated Hb (HbA1c) metabolic rate
Level TWO (2) variable value difficult to collect freq. ethical difficulties	mobility tracking material culture (production)	soil samples pest dynamics prey densities ecological impacts market dynamics	illness histories DNA seq salivary hormones/IGA hair/urine/feces doubly labeled water

Each of these domains relates to the others in an integrated fashion. As outlined at the start of this document, human adaptation is accomplished through behavior, but that behavior takes time to learn and develop, and so cannot develop without investment and exchange from other individuals. The pace of growth, cognitive development, and aging both constrain and are altered by patterns of learning, behavior, and exchange. But this is taxonomy, and the point is not that these categories make unique sense, but rather that any categorical lines drawn among behavior, cognition, and population dynamics will force an integrated perspective to unite them in the service of inference.

TABLE 1 SKETCHES THE DESIGN CONNECTIONS between each general domain (left), theoretical process comprising long-form adaptation (2nd column), operational measures (3rd column), and the inferential structure of state-based models (right). For example, progress on testing theories about social learning strategies and their population consequences is accomplished by measuring patterns of attention, association, and behavioral traits. Within an analytical model, functions map individual state (current behavior, available behavioral models, strategy) to probabilities of changing state to another behavior. More detail on the statistical framework is provided in the next major section of this document (page 10). But in principle this resembles laboratory social transmission experiments in which behavior can be observed and strategically used by participants. Measurement is harder in real, natural ecologies. But the inferentially relevant variables are known.

Analogous connections exist within other domains, as well as across domains (not shown in the table). For example, energy funds the growth of bodies, and so measurements of growth within each individual over time provide detailed information on energy transfers between individuals, as well as the connections between the pace of life history, rates of cognitive development, and patterns of learning. Statistical inference allows estimation of sensitivity of individual growth, health, and fertility to changes in exchange, household composition, and competition (with e.g. siblings). All of these issues are relevant to the question of long-form adaptation, because life history and cultural learning fit one another in yet unknown ways.

TABLE 2 ILLUSTRATES A PRAGMATIC BREAKDOWN of measurements. Anthropological fieldwork is time consuming. Technology has, so far, minimal impact on its efficiency. And so prioritizing measurements will be essential to producing comparable and consistent within-individual longitudinal data. The table shows three levels of

measurements. Individual field researchers can opt in and out of particular measures, but by providing measures across all domains within each level, a field site supports integrated inference and comparability with other sites.

The foundation level, Level Zero, comprises data that many quantitative anthropologists already collect. These do not need to be collected on every individual in every year, in order to be valuable. And often they can be collected while conducting other research, or gathered by trained field assistants.

Levels One and Two comprise increasingly difficult or costly to collect measures. The measures in Level One are of high value, provided objective measures of self-report measures from Level Zero, in addition to providing many high-value biomarkers. Even sparse time series of these variables is of great value, as they are supported by Level Zero measures and provide some validation of them. Level Two measures involve particular technologies and rich data streams that are not practical, valuable, or ethical in all contexts. In principle, each unique site will be able to take advantage of unique measurements that leverage specific technology or laboratory techniques. But these approaches are not of the same general value as measures in Levels Zero and One.

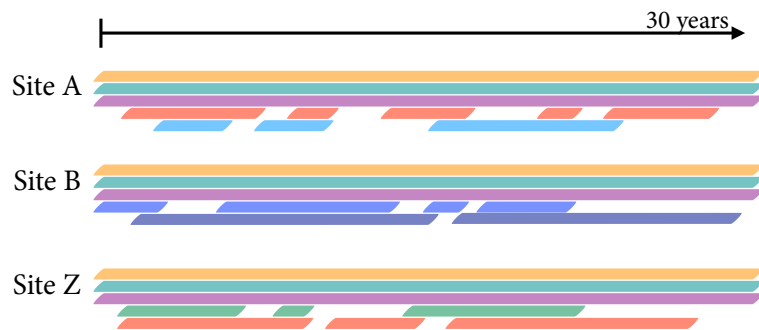


Figure 6: 30 years of long-form research. Time spans from left to right, as research unfolds at three of many parallel field sites. Comparable, basic measures are completed in each of three domains, as indicated by the three unbroken bars common to each site. These baseline measures provide a foundation for unique studies (unique broken bars) that leverage the uniqueness of each site.

Data Curation and Analysis

Data should be comparable from collection to analysis, using open and robust formats. A state-based, dynamic statistical framework allows for honest attention to uncertainty, for data to speak directly to non-null models, and for flexible model definition.

To make use of the measurements, specific structures linking data to models to inference are needed. Data capture approaches and technologies, database structures, and statistical software are integral to this kind of research program.

Two principle difficulties with current quantitative anthropology are (1) that the norms for data integrity and preservation are weak and (2) that common hypotheses about life history, sociality, and learning are investigated using incompatible modeling frameworks. These difficulties slow progress and impede the construction of a causal models that can bridge levels and time frames. An organized network for long-form field research should support improvement in both these areas.

DATA COLLECTION AND CURATION are specialized skills. Organizing data is hard, and most scientists have never received training in organizing data. As a result, data formats are usually not planned but rather evolved during data collection. Standardized and flexible database structures are possible, using open formats that are easy to archive and anonymize to protect participants' privacy. These are not hard problems to solve, given some training, but there is no reason for individual researchers to keep solving them for themselves. Thus a major initiative for long-form research to develop and refine methods of standardized data collection and curation.

STATE-BASED MODELS encourage rigor and create data comparability through causal inference rather than meta-analytic numerology. A state-based model here indicates a population dynamic model in which individuals have *states* comprising combinations of traits, whether inherited, learned, or contextual. For example, both a gene and a location are a state. State-based models are routinely used in ecology to model population dynamics.⁶ They are really a quantitative framework, used to focus inference on non-null causal models that are capable of both testing theories and making population projections.

In an instrumentation project for studying human adaptation, state-based models can integrate life history (e.g. vital rates), sociality (e.g. exchange), and learning (e.g. age specific attention strategies) within a common population dynamic model of behavior. One advantage of this approach is that it allows for an axiomatically complete accounting for how hypothesis for learning and behavior integrate at

⁶ C. Merow, J. P. Dahlgren, C. J. E. Metcalf, D. Z. Childs, M. E. K. Ecan, E. Jongejans, S. Record, M. Rees, R. Salguero-Gomez, and S. M. McMahon. Advancing population ecology with integral projection models: a practical guide. *Methods in Ecology and Evolution*, 5:99–110, 2014

the population level.⁷

All of this probably sounds overly ambitious. So it is worth emphasizing that ecologists already accomplish this, but without accounting for learning as a source of behavior change. Therefore the workflow from data to model to inference is already established in software. The proposal here is to develop a new application of such a framework, one that allows for modular hypotheses for components of the dynamics and leverages the most recent advances in Bayesian estimation.⁸ There is little point in having big data unless properly big models can be matched to it.

This kind of unified statistical framework has many advantages. It can be deployed in limited ways to address isolated questions, such as the impact of polygyny on child welfare or the impact of kinship on social exchange. But it can also be used to link such impacts to questions about the evolution of vital rates or the dynamics of cultural traditions. Developing example analyses, addressing common issues in human evolutionary ecology, could be a foundational effort to demonstrate the value of building a joint inferential framework embodying population dynamics of adaptation.

OPEN METHODS AND DATA are essential for the rigorous and transparent conduct of research. In the endeavor sketched here, open data allow others to verify analyses, find mistakes, and extend the value of data collection. Open materials allow others to critique, improve, and make use of methods of data collection and analysis. Preregistration of methods of data collection and analysis incentivize rigor and clearly demarcate testing from exploration.

In experimental sciences, preregistration has proven valuable. Preregistration looms large in importance, as it reduces practices like HARKing⁹ and *p*-hacking, the practice of trying many different analyses in search of statistically discernible differences. These practices lead research to follow noise. But in experimental sciences, replication is also possible as a substitute and complement to preregistration. In field sciences like anthropology and ecology, replication is usually impossible. This makes preregistration, whether in part or whole, all the more important.

⁷ B. Beheim and R. Baldini. Evolutionary decomposition and the mechanisms of cultural change. *Cliodynamics*, 3:217–233, 2012

⁸ <http://mc-stan.org>

⁹ Hypothesizing After Results are Known



Figure 7: Open data and materials allow repeatability and extended analysis. Preregistration publicly distinguishes hypothesis testing from data exploration and theory generation. Badges at <https://www.centerforopenscience.org/>

RIGHT TO FIRST PUBLICATION of data must reside with individual researchers and sites where it is collected. But in the case that central funds are used, if those researchers do not make use of the data within a previously agreed to time frame, the data become publicly available in a responsibly anonymized form when possible, and any-ways usable by any researcher who releases only anonymized summary statistics.

Specific and explicit sample custody agreements are also essential in all cases. We make it legal, so we can remain friends.

Orderly Chaos of a Research Network

An instrumentation project of this kind cannot be conducted in a fully centralized way. Individual sites retain autonomy and flexibility. There is an important role for a hub for coordinating exchange and development of common solutions, as well as incentivizing quality. A shifting portfolio of sites is useful to maintain diversity, buffer against unplanned interruptions, and take advantage of new opportunities.

A CENTRALIZED COORDINATING ENTITY, like the Max Planck Institute in Leipzig, can provide resources and technology to simplify the planning and collection of data. However, individual researchers will have to and must exercise their own judgment about which methods and research designs are appropriate in their context, as well as how to properly translate some methods so that what is measured is comparable, rather than just how it is measured. When it is appropriate, funding can support equipment, field assistants, site infrastructure, and other running costs. Since costs and requirements vary tremendously by context, flexibility and planning are at a premium. The reliability of base funding relieves pressure on researchers to find funding elsewhere and still leaves room for personal research initiatives. Such initiatives, when successful and practical, may be syndicated to other sites.

It is possible to look into the future of the infrastructure and consider the dynamics of the research network. Field research is often unpredictable and often interrupted. In this design, the longer a field site is run, the more valuable it becomes. But sometimes sites must close, when they cannot be passed along to new managers. Other times, new sites appear that can compensate for closures or offer new value.

This is why we envision a shifting portfolio of sites, not a stable set with fixed criteria of membership, balancing subsistence modes or political structures. There are three basic strategies for site inclusion.

ROOTS are long-running sites either based in the department in Leipzig or otherwise receiving major funding and direction from it. These sites are committed to the longitudinal project and explicitly plan for field manager succession and redundancy. They serve as well as contexts for training new field researchers who may go on to found sites of their own. Roots have priority access to analytical and computing resources in Leipzig.

SHOOTS are sites that receive maintenance funding and participate in at least Level Zero measurements, on an irregular or regular basis. These sites are managed externally to the department in Leipzig and are largely autonomous. They ideally serve as key sources of innovation

in critique and approach. Like all sites inside or outside the network, Shoots may take advantage of analytical and computing resources in Leipzig, when capacity permits.

SEEDS are stimulus grants, targeted at early-career researchers, for new research at either new field sites or existing ones. The support of Seed projects is a way to discover new scientific talent, encourage innovation, and ultimately maintain the long-form health of a long-form research network.

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