

Ad Hoc Faculty Committees to Identify Strategic Expertise

- Food and nutrition security enhanced through scientific discovery and the application of state of the art knowledge
 - Rachel Bezner Kerr -- DSOC
 - Adam Bogdanove, Lailiang Cheng, Mike Gore, Matt Ryan, Chris Smart -- SIPS
 - Michelle Cilia -- Boyce Thompson
 - Julio Giordano -- AS
 - Saurabh Mehta -- DNS
 - Katja Poveda -- ENT
 - Brad Rickard, Todd Schmit – Dyson

- Climate change -- its causes and consequences and adaptation and mitigation to safeguard biodiversity, ecosystems, sustainable farm and food systems and human well-being
 - Toby Ault -- EAS
 - Taryn Bauerle, Larry Smart -- SIPS
 - Christine Goodale, Jed Sparks -- EEB
 - Heather Huson -- AS
 - Brian Nault -- ENT
 - Ariel Ortiz-Bobea -- Dyson
 - Amanda Rodewald -- DNR
 - Todd Walter – BEE

- Social and socio-ecological system resilience under climate change, globalization and technological change, with a particular focus on economic and community dynamics
 - Shorna Allred -- DNR
 - Brian Davis -- LARCH
 - Shanjun Li -- Dyson
 - Kathryn McComas -- COMM
 - Wendy Wolford – DSOC

- Biological systems and their evolution across all hierarchical scales, from the subcellular level to complex ecosystems
 - Anurag Agrawal, Robert Reed -- EEB
 - Dan Buckley, Joss Rose, Adrienne Roeder -- SIPS
 - Robin Dando -- FS
 - Bryan Danforth, Brian Lazaro -- ENT
 - Maria Garcia-Garcia, Marcus Smolka -- MBG
 - Ian Hewson -- MICRO
 - Giles Hooker -- BSCB
 - Xingen Lei, Vimal Selvaraj -- AS
 - Melissa Warden – NBB

- “Big data” analysis and interpretation to support cutting edge research in biological, agricultural, social, communication, management and information sciences
 - Ed Buckler -- SIPS
 - Lindsay Anderson -- BEE
 - Jacob Bien -- BSCB
 - Gang Chen -- EAS
 - Carla Gomes – Dyson/IS
 - Julia Finkelstein – DNS

- Media and communication technologies
 - Sue Fussell, Jeff Hancock, Drew Margolin -- COMM
 - Jon Kleinberg, Dan Cosley -- IS
 - Aija Leiponen -- Dyson

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As is true in many areas, specialized expertise needs to be coupled with the ability to manage, analyze and interpret massive amounts of novel data. Many of the areas of expertise will have greatest scientific impact if coupled with data analytics capabilities provided by experts in areas like bioinformatics and computational biology. In recruiting expertise that will make important scientific impacts, an important consideration will be the assembly and integration of scholars with complementary knowledge and skills. With this qualification in mind, the following list highlights areas of expertise that would build on existing strengths and establish the basis for the continued prominence of the biological sciences in CALS and at Cornell.

- Evolution
 - Phylodiversity (evolutionary relationships between species)
 - Comparative phylogenomics (transcriptomes, genomes)
 - Biology of infectious diseases
 - Experimental evolution/synthetic biology (e.g., relationship between genotype and phenotype, applications like food security)

- Ecology
 - Host-microbe interactions (e.g., microbiomes, microbial ecology)
 - Microbial biogeochemistry (e.g., microbial mediation of biological cycles, geomicrobiology of the deep biosphere)
 - Biodiversity and ecosystem services

- Mechanisms and Regulation
 - Epigenetics (e.g., mechanisms of gene expression, methylation)
 - Signaling (e.g., growth control, general response to stimulus)
 - Metabolomics (e.g., secondary metabolism)
 - Connectomics (mapping and visualizing nervous system connections)

- Big Data/Technology
 - Quantitative biology including, but not limited to bioinformatics (e.g., class programming¹), computational biology, statistical genomics, systems biology)
 - Neurotechnology for the study of brain function

¹ “A *class* is a blueprint or template or set of instructions to build a specific type of object. Every object is built from a class. Object-oriented programming (OOP) is a style of programming that focuses on using *objects* to design and build applications. Object-oriented programming is used to develop many applications and developers choose to program in the object-oriented paradigm because the proper use of objects makes it easier to build, maintain, and upgrade an application.” <http://www.adobe.com/devnet/actionscript/learning/oop-concepts/objects-and-classes.html>

Expertise Needed to Impact Understanding of Causes and Consequences of Climate Change and to Adapt to and Mitigate Its Impacts

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For CALS (and more broadly Cornell) to be a leader in climate change research, teaching and extension, we must build capacity in the following key areas.

- Quantitative approaches to understand social and environmental processes operating across broad spatial and temporal scales
 - Approaches using geographic information systems, remote sensing, earth system and eddy flux system modeling to understand patterns and processes at larger than catchment scales and within a 10 to 30 year time horizon
 - Community land models that “formalize and quantify concepts of ecological climatology, an interdisciplinary framework to understand how natural and human changes in vegetation affect climate. It examines the physical, chemical, and biological processes by which terrestrial ecosystems affect and are affected by climate across a variety of spatial and temporal scales.”¹
 - Paleoclimatology (i.e. the study of change in climate taken on the scale of the entire history of the earth)

- Decision support informing adaptation to climate change
 - Forecasting change and its social and ecological impacts
 - Numerical modeling for decision support tools
 - Risk assessment and adaptive management
 - Evaluation of the physical, biological and economic viability of adaptation strategies
 - Evaluation of potential for plant and animal adaptation to climate change
 - Financial instruments that are responsive to climate change (e.g., models that can address the challenges of nonstationarity)
 - Social inequality, environmental justice and welfare policy
 - Social and economic resilience and the attenuation of the disruptive effects of climate change
 - Economic assessment of ecosystem values including carbon sequestration, flood mitigation, and biodiversity
 - Science communication of necessary actions for increased awareness of decision makers and the general public

¹ <http://www.cesm.ucar.edu/models/clm/>

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In addition to the overarching approaches described above, CALS requires expertise in the area of climate change that contributes to the attainment of:

- Food production and distribution systems responses and food security
 - Changing crop and livestock system feedbacks to climate change
 - Human health and environment impacts of crop and livestock systems change
 - Breeding crops and livestock that can withstand extreme weather conditions
 - Pests, pathogens and human disease vectors emerging with climate change
 - Physiological adaptations of plants and animals to climate change

- Energy security
 - Bioenergy options for adaptation to and mitigation of climate change
 - Bioenergy impacts on earth systems processes

- Water security
 - Ground water hydrology to address drought and unconventional resource extraction
 - Fluvial geomorphology to understand dynamic stream response under changing climatic conditions

- Environmental Security
 - Physiological and mechanistic effects on plants and animals
 - Morphological, physiological and genetic characterization of species change
 - Sustainable built environment including green infrastructure, water and energy systems, etc.

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CALS will enhance its positive impact on food and nutrition security worldwide with the addition of expertise under five themes. The impact of such expertise will be enhanced if accompanied with the following skills: ability to work across disciplines; knowledge of primary data collection, statistics and modeling; capability and interest to use the field as a living laboratory; capacity to apply knowledge and offer these applications to the public through extension and other networks.

- New technologies for improved crops that will provide food for a burgeoning population under rapidly changing climate conditions
 - Plant metabolomics with an emphasis on secondary metabolism
 - Regulation of plant photosynthesis
 - Genome editing for crop and livestock improvement
 - Discovery and characterization of chemical diversity with applications such as novel therapeutics and care of the microbiome

- Agricultural diversification and local/regional food systems
 - Plant and animal breeding that engages stakeholders and multiple disciplines
 - Landscape agroecology to integrate technology and inputs for local food system sustainability
 - Understand the benefits of farm practices that increase ecosystem services (e.g., pollination, weed control) and their effects on yield across varying contexts

- Crop and livestock improvement for climate change
 - Genetic and molecular biology of plant and animal adaptation (e.g., biotic and abiotic stress tolerance, disease and pest resistance)
 - Crop modelling to predict crop performance based on historical/current/projected climate information in combination with genome-wide genotypic information
 - Population genomics (plants, animals and microbes) to understand variation across populations to capture and mobilize useful traits
 - Genome engineering to generate *de novo* genetic variation for plant and animal species at risk of extinction, the expansion of the adaptive range, and higher yields and nutritional density

Expertise Needed to Impact Food and Nutrition Security

- Social and economic dimensions of food and nutrition security
 - Social equity including race, class and gender dimensions, and food system policy and politics
 - Identification of producer and consumer needs to inform agriculture and food technology development and policies
 - Demographics of food supply and demand
 - Societal response to agriculture and food technologies

- Food systems function and evaluation
 - Computational biology and statistical modeling with the ability to integrate massive amounts of diverse data and develop new analytic methods
 - Evaluation of the safety of new technology for consumers, producers and the environment
 - Quantitative description and prediction across the biological, production, economic, and social domains to improve understanding and management of food system performance
 - Assessment of social, economic and ecosystem service effects of regional and local food systems
 - Methods of food and nutrition security assessment, including the validation of methods

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- Advancing computational social science
 - Computational social science: integrate computational methods with social science theory
 - Media choices across time and in different contexts
 - Social media's effect on mental and physical health
 - Social networks and media technology
 - On-line behavior

- Design and problem solving
 - Innovation in human computation (crowd sourcing, citizen science, shared economy)
 - Digital communities and culture, technologically designed organizations/social systems
 - Reason-based public deliberation in the context of media saturation
 - Design of systems supporting social networks and interaction
 - Societal change and the consequences of the digital society (e.g., the digital divide)
 - Informatics for sustainability in addition to environmental, agricultural, health, crisis management and other applications

- Ethics, law, policy and regulation
 - Privacy and security
 - Ground rules for pooling citizen data and collective action
 - Intellectual property and governance of open/shared data

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- Behavioral Social Science
 - Decision science
 - Field experiments
 - Adaptive/reactive behaviors (e.g., migration)

- Environmental policy and politics
 - Macro policy design and evaluation
 - Vulnerable populations/human rights/ethics (e.g., climate justice)
 - Adaptation policy

- Integrated landscape science and nexus (air, land, water) development
 - The marine-terrestrial interface and ecological resilience
 - Subsurface resource extraction (economics, dynamic optimization modeling, economic/ecological tradeoffs)

- Spatial and material practices
 - Spatial inequality
 - Infrastructure studies
 - Landscape design and evaluation
 - Protected areas, parks and conservation

- Socio-ecological risk and adaptation
 - Entrepreneurship and adaptation
 - Ecosystem services
 - Multi-objective tradeoff analysis
 - Changing ecosystems and human health

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Scholarship in the area of big data will be advanced by experts who combine domain knowledge (e.g., biology, agriculture, climatology, information science) with methods and techniques for analyzing and processing very large data in parallel: “structured and unstructured data that is so large that it is difficult to process using traditional database and software techniques.”¹ Also, this expertise needs to be disseminated to domain experts who require big-data capabilities. In this respect, instruction of students in methods for processing and analyzing big data is needed. Specific expertise that would make CALS impactful in the area of big data is summarized in four broad areas below:

- Scientific computation
 - Computational platforms and tools to handle massive-scale processing of fine-grained data (e.g., geospatial, genomic, social)
 - Data analytics for novel techniques in extracting information from large data sets
 - Image processing (e.g., neural networks)
 - Data visualization and graphic display
 - Computational fluid dynamics across scales, connecting large-scale predictions with local applications (e.g., climate)
 - Integration of data across domains (e.g., agriculture, atmosphere, soil, water)
 - Bioinformatics

- Statistics
 - High-dimensional statistics, causal inference, network data, correlated data
 - Predictive analytics or use of large data sets to develop predictive models
 - Extreme value theory for applied probability
 - Spatial and temporal analysis
 - Spatial statistics and geospatial information science

- Modeling
 - Physiological modeling
 - Biophysical process modeling in biological, agricultural, and environmental systems
 - Multi-scale modeling
 - Decision support systems
 - Sophisticated optimization
 - Sequential decision-making
 - Simulations

¹ http://www.webopedia.com/TERM/B/big_data.html

Expertise Needed to Impact Scholarship in Big Data

- Methodology and technology
 - Advanced remote sensing for landscape-scale characterization, inventory, and mapping of environmental processes and resources
 - Machine learning and understanding
 - Scalable algorithms and methods for continuous extraction and analysis of streaming data; performance of reproducible computational analyses
 - Parallel implementations of a range of known algorithms (e.g., matrix computations, statistical operations, optimization methods, machine learning)
 - Privacy and security in data mining and analysis
 - Quantitative and computational methods for analysis of geospatial data
 - Characterizing uncertainty, date (scenario) reduction
 - Field-based instrumentation
 - Proximal sensing from terrestrial and unmanned aerial systems for precision management and analytics