NEW GRADUATE CONCENTRATION PROPOSALS
ARIZONA STATE UNIVERSITY
GRADUATE COLLEGE

This form should be used for academic units wishing to propose a new concentration for existing graduate degrees.

A concentration is a subspecialty within a degree and major which reflects that the student has fulfilled a designated, specialized course of study which qualifies the student as having distinctive skills and training in one highly concentrated area of the major. Concentrations are formally-recognized educational designations (including the assignment of a university plan code for reporting/record-keeping purposes and appearance on the ASU transcript). Concentrations are to be distinguished from not formally recognized academic distinctions frequently referred to as "emphases," "tracks," "foci," "options," etc.

Submit the completed and signed (chairs, unit deans) proposal to the **Office of Graduate Academic Programs.** Mail code 1003 and electronic copies to ozel@asu.edu or Denise.Campbell@asu.edu

Please type.

Contact Name(s): Michael Barton	Contact Phone(s): 480-965-6262/6213 or 480-727-9746
College/School/Division Name: CLAS/SBS	
Academic Unit Name: School of Human Evolution & Social Change (SHESC) for program administration, jointly administered with the School of Life Sciences (SoLS) and the School of Sustainability (SOS)	
Existing Graduate Degree and Major under which this concentration will be established: Doctor of Philosophy (PhD) for **1)** Anthropology, **2)** Applied Mathematics in the Life & Social Sciences, **3)** Global Health, **4)** Environmental Social Science, **5)** Sustainability, and **6)** Biology	
Proposed Concentration Name: Complex Adaptive Systems Science (CASS)	
Requested Effective Term and Year: Fall 2011 (*e.g. Spring 2010*)	
Do Not Fill in this information: <u>Office Use Only</u> **Plan Code:**	**CIP Code:**

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1. Overview

A. Provide a brief description (*not to exceed 250 words*) of the new concentration (including the specific focus of the new concentration, relationship to other concentrations in this degree program, etc).

We propose to create a new interdisciplinary doctoral concentration (implemented as six parallel concentrations in six PhD programs of three academic units, with an interdisciplinary, collaborative administrative structure) that trains the next generation of scientists in advanced concepts and methods needed for approaching diverse phenomena in the social and life sciences as **complex adaptive systems** (***CAS***). This educational program will be tightly integrated with diverse, ongoing, university-wide research on CAS at Arizona State University and will emphasize the value of a CAS perspective to giving science better insight and a more active role in seeking solutions to a broad array of critical issues facing our society today. Importantly, CAS concepts and tools can serve as a common language to promote interdisciplinary collaborations needed to come to grips with the intellectual and societal challenges of the 21st Century. We propose to make students fluent in the common language of complexity while also ensuring that they receive a solid foundation in the domain knowledge of existing academic disciplines. By broadly embedding an understanding of CAS-relevant approaches into the practice of normal science, we seek not only to transform science, but also promote the development and testing of more robust theory and more sophisticated methods by applying CAS-enabled science in a wider array of research settings. This is needed to develop a deeper understanding of the nature and dynamics of CAS, grounded in concrete examples and applications rather than abstract theory.

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2. Impact Assessment

A. Explain the unit's need for the new concentration (e.g., market demand, research base, direction of the discipline, and interdisciplinary considerations). How will the new concentration complement the existing degree program, including enrollment, national ranking, etc?

Many phenomena of critical relevance to human society are dynamic systems that change over individual and evolutionary time scales, and are highly interactive, both within and between systems. That is, they are complex adaptive systems (CAS). As a consequence, many social and natural systems share isomorphic properties like near-decomposability, hierarchical organization, scale-free networks, self-organized criticality, and emergence that are inherent to the structure, operation, and dynamics of CAS.

The spread of epidemics, society-biology interactions of obesity, impacts of agriculture on land degradation, ecological impacts of urban growth, and social responses to natural disasters all involve CAS.

Human societies have made the modern world more complex than ever before, with over 6 billion individuals, living in urban centers of millions of inhabitants, divided into innumerable social and economic roles, and organized into hierarchies many levels deep. As a result, earth's biophysical systems and human society are increasingly and more tightly interlinked in a web of dynamic interactions that spans the globe. The prevalence of non-linearities and unexpected emergent properties in CAS, means that the simple cause and effect thinking which has served our species well for so long may no longer offer reliable predictions of the outcomes of social action—even when systematized in the careful trial and error learning that has made western science so successful. Without a better understanding of the non-intuitive properties of CAS, we face growing uncertainty about the outcomes of institutional decisions in complex socioecological systems (SES), where increasingly tight couplings across these systems that can globally propagate and amplify cascades of unexpected and undesirable consequences.

To respond to this challenge, some institutions have created new academic programs around the theme of complexity (e.g., UCLA Human Complex Systems Program <http://hcs.ucla.edu/> and the George Mason University program in Computational Social Sciences <http://socialcomplexity.gmu.edu/phd.php>). Focusing intellectual energy into a new, specialized domain of complexity may help to understand the phenomena of complex systems in general, but we contend that it is even more urgent to embed CAS concepts and methods within existing social, behavioral, and life sciences so that they can play a more active role in solving real-world problems. For this reason, we are seeking to establish an integrated, interdisciplinary doctoral concentration in Complex Adaptive Systems Science within a series of academic units at ASU.

Students' career opportunities will be enhanced by combining fluency in the common language of complexity with a solid foundation in the domain knowledge of existing academic disciplines. There is a clear and growing need for young scientists to be able to work and collaborate in an increasingly interdisciplinary context. This and the recent recognition of the value of CAS approaches is leading to a growing demand for researchers who are able to apply the concepts and methods of complex systems approaches to the study of dynamic socio-natural systems as well as relevant policy decisions —demand that will grow in coming decades. Moreover, most of the few graduate programs that offer training in complex systems approaches are aimed at computation and computer science, physical systems, or engineering rather than the self-organized, dynamic CAS that characterize living organisms, ecosystems, and human societies. Therefore, we plan to create an integrative educational framework in which the common language of complexity can be embedded comprehensively within different academic programs to give the next generation of scientists the conceptual tools to create meaningful collaborations across the social and life sciences. Systematically training young scientists in the theory and methodological protocols needed to apply a complex systems perspective will put them at the forefront of their fields, enhancing their career opportunities. This is especially important for members of underrepresented groups, where expertise in complex systems approaches can help them distinguish themselves from others seeking jobs their field.

B. Please identify other **related** ASU programs and outline how the new concentration will complement these existing ASU programs? **(If applicable, statements of support from potentially-affected academic unit administrators need to be included with this proposal submission.)**

There are no existing academic programs directly related to the proposed CAS Sciences concentration at ASU. However, there are several academic programs, which can contribute to and benefit from participation in this interdisciplinary doctoral concentration. We initially applied for planning permission for this concentration only for SHESC. However, we subsequently submitted an NSF IGERT proposal that identified a number of other academic programs that desired to contribute to such a concentration. Here we are only proposing to involve three of those units to initiate this broader interdisciplinary CASS Concentration: the School of Human Evolution & Social Change (SHESC), the School of Life Sciences (SoLS), and the School of Sustainability (SoS). These three units have shared faculty and already collaborate on a number of complexity-related initiatives (e.g., CASI). Included with this proposal are letters from the directors of all three academic units expressing their interesting in participating in this concentration. After the CASS Concentration is operating, we hope to be able to offer participation to other relevant academic units, including those identified in the IGERT proposal: the school of Geographical Sciences and Urban Planning, the Department of Psychology, and the School of Public Affairs. Faculty from these programs are listed among those with an interest in participating in this cross-disciplinary CASS concentration.

C. Is this an interdisciplinary concentration? If yes, please address the relationship of the proposed concentration to other existing degree programs and any parallel or similar concentrations in these degree programs. **(Please include relevant Memoranda of Understanding regarding this interdisciplinary concentration from all applicable academic units.)**

This is an interdisciplinary academic program that will be established as parallel doctoral concentrations within participating graduate programs. We have attached letters of support from the directors of the academic units involved. Relevant doctoral degree programs are sufficiently open such that the proposed concentration requirements will require no or minimal additional coursework on the part of students. We have listed this for each degree in part 3F below. Note that because this is proposed to operate as an integrated academic program, even though it must be administratively implemented as six related concentration across multiple degrees, we are combining the information for all the degrees in this single form for efficiency of review. However, there is a separate table 3F for each degree involved.

3. Academic Requirements and Curriculum

    A. What are the total minimum hours required for the major and degree under which the proposed concentration will be established?

84 for each of the following PhD programs: AMLSS, Anthropology, Biology, Environmental Social Science, Global Health, Sustainability

    B. Please provide the admissions criteria for the proposed concentration. If they are identical to the admission criteria for the existing major and degree program under which this concentration will be established, you may attach a copy of these criteria as they appear on the departmental website, or other source (please indicate source). Please also list all undergraduate and graduate degrees and/or related disciplines that are required for admission to this concentration program.

Incoming students must meet admissions criteria and be accepted into one of the six participating doctoral degree program, <u>before</u> they can apply to the interdisciplinary CASS concentration. The application materials of accepted students who declare an interest in the CASS program will be forwarded to a CASS graduate faculty (see below) for review and admission to the concentration. All students accepted to the CASS program will choose or be assigned a CASS faculty mentor to advise her/his academic progress in the CASS concentration. Normally all students in participating in a CASS concentration will have at least one member of the CASS graduate faculty as a member of their doctoral supervisory committee; exemptions (e.g., for a faculty member with strong expertise in CAS but who is not a member of the CASS graduate faculty) can be requested and will need approval by the CASS graduate faculty. The student's committee will decide if any remedial coursework is needed in order to complete the requirements of the CASS concentration along with their relevant academic PhD program (see also Appendix for additional discussion of entry level skills and deficiencies).

    C. If the proposed concentration is part of a larger, interdisciplinary agenda, please provide additional admission information related to students who may enter with various academic backgrounds, including expected entry-level competencies. As applicable, please also address the courses that must be taken to remedy any relevant deficiencies for incoming students.

Please see above and Appendix .

    D. What knowledge, competencies, and skills (learning outcomes) should students have when they graduate from this proposed concentration program? Examples of program learning outcomes can be found at (http://www.asu.edu/oue/assessment.html).

This is planned as a concentration to enhance existing doctoral programs. Our goal for graduates is that they become agents of transformation *within the traditional disciplines* in which they earn their doctorates, as they apply a CASS perspective in their disciplinary science and education. To do this, they will need to learn fundamental knowledge of CASS and new quantitative and computational methods for studying CASS and their dynamics in order to apply them to issues within their disciplinary specializations. We also aim for young scientists trained in this program to learn to frame new research questions envision new approaches to existing questions because of their ability to perceive biological and social systems as CASS. Moreover, because of the isomorphic properties that underlie CAS, the concepts and protocols of complexity can serve as a new common language to facilitate new syntheses and bridge across scientific disciplines that deal with interconnected socio-ecological systems, much like advanced mathematics serves as a common language for engineering and the physical sciences. We aim for graduates to learn to use the common language of CASS to lead collaborative research across the social, behavioral, and life sciences.

    E. How will students be assessed and evaluated in achieving the knowledge, competencies, and skills outlined in 3.D. above?

        Examples of assessment methods can be found at (http://www.asu.edu/oue/assessment.html).

Because this is an interdisciplinary concentration within existing doctoral programs, students must first be assessed and evaluated according to the metrics of these programs. Additionally, their success in the concentration will be evaluated by three other metrics. One of these is grades in CASS courses. The second is an annual self-evaluation in which each student will assess his/her progress in learning CASS concepts and methods and applying them to relevant issues in his/her home discipline. This self-evaluation will be reviewed by the CASS graduate faculty; the student's CASS mentor/PhD committee member will respond to the student summarizing the faculty evaluation. The third way is that each student must apply CASS concepts and methods in his/her doctoral dissertation, advised by a supervisory committee that includes a member of the CASS graduate faculty, and successfully defend that dissertation.

F. Please provide the curricular structure for the proposed concentration.

- Additionally, please ensure that all **<u>new</u>** required course proposals have been submitted to the Provost's office through the ACRES online course proposal submission system for approval before this concentration is put on the University Graduate Council and CAPC agendas.

A table has been provided for programs of study in <u>each</u> of the of the six PhD programs participating in this concentration.

1) Required Core Courses for the PhD in Anthropology Degree			Credit Hours
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **9**
ASB540	Scholarly Inquiry in Anthropology	no	**3**
ASM565 or equivalent	Quantitative Archaeology or equivalent quantitative methods class	no	**3**
ASM579 or equivalent	Proposal writing or equivalent	no	**3**
Required Concentration Courses			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **12**
ASM570	Fundamentals of CASS	yes	**3**
One of the following AML610 AML591 ASM591	<u>One</u> course in mathematics of CASS Topics in Applied Mathematics for the Life and Social Sciences Probability Theory Dynamic Modeling in Social and Ecological Systems *…or equivalent*	no	**3**
One of the following AML612 AML591 ASM591 PUP598 CES561 PAF591	<u>One</u> course in modeling CASS Choose from… Applied Mathematics for the Life and Social Sciences Modeling Seminar Agent Based Modeling Dynamic Modeling in Social and Ecological Systems Modeling and Simulating Urban Environments Modeling & Simulation Theory & Application Introduction to Policy Informatics *…or equivalent*	no	**3**

One of the following ASM591/BIO591 PAF591 SOS598 PSY576 PSY598 ANB602 BIO591 BIO522 BIO545	<u>*One* course in application of CASS approaches within discipline.</u> *Choose from…* Readings in Complexity Complexity in Public Policy & Management Social Network Analysis Dynamics in Psychology Dynamics in Perception, Action, & Cognition Current Issues in Animal Behavior Topics in Mathematics for Life and Sustainability Science Populations: Evolutionary Ecology Populations: Evolutionary Genetics *…or equivalent*	no	**3**

Elective or Research Courses *(as deemed necessary by supervisory committee)*			**<u>Credit Hours</u>**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **21**
	Other electives	no	**9**
	Research (CASS related)	no	**3**
	Research (degree related)	no	**9**

<u>Culminating Experience</u> ***E.g.*** *- Capstone project, applied project, **<u>thesis</u>** (**<u>masters only</u>** – 6 credit hours) or **<u>dissertation</u>** (**<u>doctoral only</u>** – 12 credit hours) as applicable*	**<u>Credit Hours</u>** **(Insert Section Sub-total)** **12**
Doctoral Dissertation	**12**

<u>Other Requirements</u> ***E.g.*** *- Internships, clinical requirements, field studies as applicable*	**<u>Credit Hours</u>** **(Insert Section Sub-total)** **30**
<u>*For doctoral programs*</u> *– as approved by the student's supervisory committee, the program can allow 30 credit hours from a previously awarded master's degree to be used for this program. As applicable, please indicate the total credit hour allowance that will be used for this program.*	**30**
Total required credit hours	**84**

2) Required Core Courses for the PhD in Environmental Social Science Degree			Credit Hours
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **21**
ESS501	Environmental Social Science: Theory and Practice I	no	**3**
ESS502	Environmental Social Science: Theory and Practice II	no	**3**
ASM579 or equivalent	Proposal writing or equivalent	no	**3**
Three of the Following ESS510 ESS511 ESS512 ESS513 ESS514	Three courses covering the methods and theories of the topical foci of ESS Urban Environments Origins and Consequences of Technologies Landscapes Institutions, Society and the Environment Health and the Environment	 no no no no no	**9**
One of the Following SSH603 SSH591	Course with the specific focus determined based on the student's interest and research plan Research Design and Proposal Writing in Social Science and Health Research Design and Proposal Writing in Anthropology	 no no	**3**
	2 courses that provide intensive background in some area of science and 6 CrHr electives (**can be met by CASS Concentration courses)**	no	
Required Concentration Courses			Credit Hours
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **12**
ASM570	Fundamentals of CASS	yes	**3**
One of the following AML610 AML 591	*One course in mathematics of CASS* Topics in Applied Mathematics for the Life and Social Sciences Probability Theory *…or equivalent*	no	**3**

One of the following AML612 AML591 ASM591 PUP598 CES561 PAF591 BIO545	*One course in modeling CASS Choose from…* Applied Mathematics for the Life and Social Sciences Modeling Seminar Agent Based Modeling Dynamic Modeling in Social and Ecological Systems Modeling and Simulating Urban Environments Modeling & Simulation Theory & Application Introduction to Policy Informatics Populations: Evolutionary Genetics *…or equivalent*	no	**3**
One of the following ASM591/BIO591 PAF591 SOS598 PSY576 PSY598 ANB502 BIO591 BIO522	*One course in application of CASS approaches within discipline. Choose from…* Readings in Complexity Complexity in Public Policy & Management Social Network Analysis Dynamics in Psychology Dynamics in Perception, Action, & Cognition Current Issues in Animal Behavior Topics in Mathematics for Life and Sustainability Science Populations: Evolutionary Ecology *…or equivalent*	no	**3**

Elective or Research Courses *(as deemed necessary by supervisory committee)*			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **9**
	Research (CASS related)	no	**3**
	Research (degree related)	no	**6**

Culminating Experience ***E.g.*** *- Capstone project, applied project, **thesis** (**masters only** – 6 credit hours) or **dissertation** (**doctoral only** – 12 credit hours) as applicable*	**Credit Hours** **(Insert Section Sub-total)** **12**
Doctoral Dissertation	**12**

Other Requirements ***E.g.* -** *Internships, clinical requirements, field studies as applicable*	**Credit Hours** **(Insert Section Sub-total)** **30**

For doctoral programs – as approved by the student's supervisory committee, the program can allow 30 credit hours from a previously awarded master's degree to be used for this program. As applicable, please indicate the total credit hour allowance that will be used for this program.	30
Total required credit hours	**84**

3) Required Core Courses for the PhD in Social Science & Health Degree			Credit Hours
(Prefix & Number)	*(Course Title)*	*(New Course?)* Yes or No?	**(Insert Section Sub-total)** **21**
ASB591/ SSH510	Health: Social and Bio-cultural Theories	no	**3**
ASB500 or equivalent	Ethnographic Research Methods	no	**3**
SSH511, ASB591, or equivalent	Ethics, Social Justice, and Health Social Science Poverty, Social Justice, and Global Health Or Equivalent	No No no	**3**
	A research design/proposal writing course	No	**3**
	At least 2 advanced statistical courses (1 or more can be met by CASS Concentration course)	no	**3**
	At least one advanced course in epidemiology		**3**
	At least 2 additional methods courses **(can be met by CASS Concentration courses)**		
	A relevant community-based internship/practicum	no	**3**
	A foreign language		
Required Concentration Courses			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?)* Yes or No?	**(Insert Section Sub-total)** **12**
ASM570	Fundamentals of CASS	yes	**3**
One of the following AML610 AML 591	*One course in mathematics of CASS* Topics in Applied Mathematics for the Life and Social Sciences Probability Theory *…or equivalent*	no	**3**

One of the following AML612 AML591 ASM591 PUP598 CES561 PAF591 BIO545	*One course in modeling CASS Choose from…* Applied Mathematics for the Life and Social Sciences Modeling Seminar Agent Based Modeling Dynamic Modeling in Social and Ecological Systems Modeling and Simulating Urban Environments Modeling & Simulation Theory & Application Introduction to Policy Informatics Populations: Evolutionary Genetics *…or equivalent*	no	**3**
One of the following ASM591/BIO591 PAF591 SOS598 PSY576 PSY598 ANB502 BIO591 BIO522	*One course in application of CASS approaches within discipline. Choose from…* Readings in Complexity Complexity in Public Policy & Management Social Network Analysis Dynamics in Psychology Dynamics in Perception, Action, & Cognition Current Issues in Animal Behavior Topics in Mathematics for Life and Sustainability Science Populations: Evolutionary Ecology *…or equivalent*	no	**3**

Elective or Research Courses *(as deemed necessary by supervisory committee)*			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **9**
	Research (CASS related)	no	**3**
	Research (degree related)	no	**6**

Culminating Experience ***E.g.*** *- Capstone project, applied project, **thesis** (**masters only** – 6 credit hours) or **dissertation** (**doctoral only** – 12 credit hours) as applicable*	**Credit Hours** **(Insert Section Sub-total)** <u>**12**</u>
Doctoral Dissertation	**12**

Other Requirements ***E.g.*** *- Internships, clinical requirements, field studies as applicable*	**Credit Hours** **(Insert Section Sub-total)** **30**

For doctoral programs – as approved by the student's supervisory committee, the program can allow 30 credit hours from a previously awarded master's degree to be used for this program. As applicable, please indicate the total credit hour allowance that will be used for this program.	**30**
Total required credit hours	**84**

4) Required Core Courses for the PhD in Applied Mathematics for the Life and Social Sciences Degree			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **24**
AML610	Topics in AMLSS	no	**3**
AML611	Research Design and Proposal Writing	no	**3**
AML612	AMLSS Modeling Seminar (meets CASS requirement)	No	**3**
AML613	Probability and Stochastic Modeling for LSS (meets CASS requirement)	no	**3**
	One course in bio-statistics	no	**3**
	Elective and Research Courses At least 6 hours in the Life Sciences and 6 hours in the Social Sciences (6 hrs meet CASS requirements)	no	**6**
	One course in Numerical Analysis	no	**3**
Required Concentration Courses			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **6**
ASM/BIO570	Fundamentals of CASS	yes	**3**
One of the following AML610 AML 591	*One course in mathematics of CASS* Topics in Applied Mathematics for the Life and Social Sciences Probability Theory *…or equivalent* **(met with AMLSS requirements)**	no	

One of the following AML612 AML591 ASM591 PUP598 CES561 PAF591 BIO545	*One* course in modeling CASS *Choose from…* Applied Mathematics for the Life and Social Sciences Modeling Seminar Agent Based Modeling Dynamic Modeling in Social and Ecological Systems Modeling and Simulating Urban Environments Modeling & Simulation Theory & Application Introduction to Policy Informatics Populations: Evolutionary Genetics (met with AMLSS requirements) *…or equivalent* **(met with AMLSS requirements)**	no	
One of the following ASM591/BIO591 PAF591 SOS598 PSY576 PSY598 ANB502 BIO591 BIO522	*One* course in application of CASS approaches within discipline. *Choose from…* Readings in Complexity Complexity in Public Policy & Management Social Network Analysis Dynamics in Psychology Dynamics in Perception, Action, & Cognition Current Issues in Animal Behavior Topics in Mathematics for Life and Sustainability Science Populations: Evolutionary Ecology *…or equivalent*	no	**3**

Elective or Research Courses *(as deemed necessary by supervisory committee)*			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?)* Yes or No?	**(Insert Section Sub-total)** **12**
	Research (CASS related)	no	**3**
	Research (degree related)	no	**9**
Culminating Experience *E.g.* - *Capstone project, applied project,* ***thesis*** *(****masters only*** *– 6 credit hours) or* ***dissertation*** *(****doctoral only*** *– 12 credit hours) as applicable*			**Credit Hours** **(Insert Section Sub-total)** **12**
Doctoral Dissertation			**12**
Other Requirements *E.g. -* *Internships, clinical requirements, field studies as applicable*			**Credit Hours** **(Insert Section Sub-total)** **30**

For doctoral programs – as approved by the student's supervisory committee, the program can allow 30 credit hours from a previously awarded master's degree to be used for this program. As applicable, please indicate the total credit hour allowance that will be used for this program.	**30**
Total required credit hours	**84**

5) Required Core Courses for the PhD in Sustainability Degree			Credit Hours
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **18**
SOS510	Perspectives on Sustainability	no	**3**
SOS511	Introduction to Research Methods in Sustainability	no	**3**
SOS512 SOS513 SOS514 SOS515 SOS516 SOS591 SOS591	In addition, students must take 6 hours of the following if admitted with a Master's Degree and 9 hours with a Bachelor's Degree Sustainable Resource Allocation Science for Sustainability Human Dimensions of Sustainability Industrial Ecology and Design for Sustainability Science, Technology and Public Affairs Uncertainty and Decision Making Sustainability and Enterprise	no	**6**
SOS530 SOS532 SOS533 SOS534 SOS535 SOS536 SOS591 SOS598	At least one Challenge Area Seminar: International Development and Sustainability Sustainable Urban Dynamics Sustainable Water Sustainable Energy and Material Use Sustainable Ecosystems Food System Sustainability Legal Issues in Sustainability Urban Ecological Systems	no	**3**
	Required Solutions Workshop	no	**3**
Required Concentration Courses			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **12**
SOS 570	Fundamentals of CASS	yes	**3**
One of the following AML610 AML 591	*One course in mathematics of CASS* Topics in Applied Mathematics for the Life and Social Sciences Probability Theory *…or equivalent*	no	**3**

	One course in modeling CASS Choose from…		
One of the following AML612 AML591 ASM591 PUP598 CES561 PAF591 BIO545	Applied Mathematics for the Life and Social Sciences Modeling Seminar Agent Based Modeling Dynamic Modeling in Social and Ecological Systems Modeling and Simulating Urban Environments Modeling & Simulation Theory & Application Introduction to Policy Informatics Populations: Evolutionary Genetics *…or equivalent*	no	**3**
One of the following ASM591/BIO591 PAF591 SOS598 PSY576 PSY598 ANB502 BIO591 BIO522	*One course in application of CASS approaches within discipline.* *Choose from…* Readings in Complexity Complexity in Public Policy & Management Social Network Analysis Dynamics in Psychology Dynamics in Perception, Action, & Cognition Current Issues in Animal Behavior Topics in Mathematics for Life and Sustainability Science Populations: Evolutionary Ecology *…or equivalent*	no	**3**

Elective or Research Courses *(as deemed necessary by supervisory committee)*			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **12**
	Research (CASS related)	no	**3**
	Research (degree related)	no	**9**

Culminating Experience ***E.g.*** - *Capstone project, applied project, **thesis** (**masters only** – 6 credit hours) or **dissertation** (**doctoral only** – 12 credit hours) as applicable*	**Credit Hours** **(Insert Section Sub-total)** **12**
Doctoral Dissertation	**12**

Other Requirements ***E.g.*** - *Internships, clinical requirements, field studies as applicable*	**Credit Hours** **(Insert Section Sub-total)** **30**

For doctoral programs – as approved by the student's supervisory committee, the program can allow 30 credit hours from a previously awarded master's degree to be used for this program. As applicable, please indicate the total credit hour allowance that will be used for this program.	**30**
Total required credit hours	**84**

6) Required Core Courses for the PhD in Biology Degree			Credit Hours
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **0**
	No required courses		
Required Concentration Courses			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)** **12**
BIO570	Fundamentals of CASS	yes	**3**
One of the following AML610 AML 591	*One course in mathematics of CASS* Topics in Applied Mathematics for the Life and Social Sciences Probability Theory *…or equivalent*	no	**3**
One of the following AML612 AML591 ASM591 PUP598 CES561 PAF591 BIO545	*One course in modeling CASS Choose from…* Applied Mathematics for the Life and Social Sciences Modeling Seminar Agent Based Modeling Dynamic Modeling in Social and Ecological Systems Modeling and Simulating Urban Environments Modeling & Simulation Theory & Application Introduction to Policy Informatics Populations: Evolutionary Genetics *…or equivalent*	no	**3**

One of the following ASM591/BIO591 PAF591 SOS598 PSY576 PSY598 ANB502 BIO591 BIO522	*One course in application of CASS approaches within discipline.* *Choose from…* Readings in Complexity Complexity in Public Policy & Management Social Network Analysis Dynamics in Psychology Dynamics in Perception, Action, & Cognition Current Issues in Animal Behavior Topics in Mathematics for Life and Sustainability Science Populations: Evolutionary Ecology *…or equivalent*	no	**3**
Elective or Research Courses *(as deemed necessary by supervisory committee)*			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?)* *Yes or No?*	**(Insert Section Sub-total)** **30**
	Other electives	no	**18**
	Research (CASS related)	no	**3**
	Research (degree related)	no	**9**
Culminating Experience ***E.g.*** *- Capstone project, applied project, **thesis** (**masters only** – 6 credit hours) or **dissertation** (**doctoral only** – 12 credit hours) as applicable*			**Credit Hours** **(Insert Section Sub-total)** **12**
Doctoral Dissertation			**12**
Other Requirements ***E.g. -*** *Internships, clinical requirements, field studies as applicable*			**Credit Hours** **(Insert Section Sub-total)** **30**
For doctoral programs *– as approved by the student's supervisory committee, the program can allow 30 credit hours from a previously awarded master's degree to be used for this program. As applicable, please indicate the total credit hour allowance that will be used for this program.*			**30**
Total required credit hours			**84**

G. Please describe the primary course delivery mode, (e.g., online, face-to-face, off-site etc.). **Please note:** If this proposed initiative will be offered **completely** online, clearly state that in this section.

Primary course delivery mode will be face-to-face. Some modeling courses will be presented as hybrid face-to-face + online mode in order to better accommodate the subject matter.

H. Please **describe** the culminating experience(s) required for completion of the existing degree and major, and the proposed concentration (e.g., thesis, dissertation, comprehensive exams, capstone course(s), practicum, applied projects, etc.).

Culminating experiences will include a comprehensive exam and doctoral dissertation. The formats of the exam and dissertation are determined by the faculty of the relevant doctoral degree in which the student is enrolled. However, the student's doctoral dissertation must represent a significant contribution to the theory, methods, and/or application of CASS approaches within the student's primary discipline.

I. Please **describe** any other requirements for completion of the existing degree and major, and the proposed concentration (e.g., internships, foreign language skills, etc.).

No other requirement. However, we envision that students in the CASS concentration can follow one of at least two tracks: a more theoretical/mathematical and a more domain/applied track. At this time, we see these as being more a matter of negotiation between the student and his/her supervisory committee than formal tracks. This could change as the concentration is implemented and evolves. For each of these informal tracks, a student's committee may encourage him/her to take courses that have prerequisites (e.g., differential equations) not required by this concentration. (See Appendix for entry level skills)

J. **For interdisciplinary programs**, additional sample curricular structures must be included as appendix items to this proposal relating to students with various academic backgrounds who may pursue the proposed concentration, including expected mastery of core competencies (e.g., course work, skills, and/or knowledge).

See Appendix

4. Administration and Resources

A. How will the proposed concentration be administered (including recommendations for admissions, student advisement, retention etc.)? Describe the administering body in detail, especially if the proposed concentration is part of a larger interdisciplinary agenda. How will the graduate support staff for this proposed concentration program be met?

The concentration will be administered by a graduate faculty in complex adaptive systems (GFCAS). The GFCAS will be drawn from the members of the graduate faculties of the participating degree programs who are qualified to chair and sit on doctoral degree supervisory committees. Initially we will ask faculty members to self-select membership in this body based on their research and teaching interests in CAS. Subsequently, the members of the GFCAS may establish more formal guidelines for admitting new members to the GFCAS. Because we are initially proposing this within a single school (SHESC), the graduate support staff from SHESC, SoLS, and SOS will work jointly to support the concentrations in this interdisciplinary CASS program. If the GFCAS grows beyond six individuals, an executive committee, consisting of one members of each participating degree program will be elected to handle day-to-day management of the concentration in CASS.

B. How many students will be admitted immediately following final approval of the concentration? What are enrollment projections for the next three years?

In the first year, we will admit 1-3 students from each participating doctoral degree. This will provide a diverse group of students to interact across disciplines, begin to develop a sense of community and ensure there are sufficient students for graduate seminars, while leaving seats for non-concentration students. We anticipate continuing to admit students at this rate for the first three years, with the number of admissions in subsequent years related to faculty that actively contribute to the program.

C. What are the resource implications for the proposed concentration, including any projected budget needs? For Doctoral students, how will the students be supported financially? Will new books, library holdings, equipment, laboratory space and/or personnel be required now or in the future? If multiple units/programs will collaborate in offering this concentration please discuss the resource contribution of each participating program. Letters of support must be included from all academic units that will commit resources to this concentration.

We do not anticipate any new resource implications for this program. It can be started and maintained with current faculty. Students in the program will be funded through their home academic units. To the extent that any new faculty are hired in support of the ASU's new Complex Adaptive Systems Initiative, they could become members of the GFCAS. Letters of support from SHESC, SoLS, and SoS are attached.

D. Please list the primary faculty participants regarding this proposed concentration. For interdisciplinary concentrations, please include the relevant names of faculty members from across the University.

Note that this is a preliminary list. There are other faculty who have expressed interest in participating in this program once it is started.

Name	Title	Area(s) of Specialization as they relate to proposed concentration
C. Michael Barton	Professor (SHESC)	Complex socio-ecological systems, long-term ecology, geospatial and agent-based modeling
Sander van der Leeuw	Professor (SHESC & SoS)	Complex adaptive systems, social complexity, dynamics of innovation and evolution of technology
Marco Janssen	Associate Professor (SHESC)	Complex socio-ecological systems, resource management, game theory, decision-making, agent based modeling
Marty Anderies	Associate Professor (SHESC)	Bioeconomics of socio-ecological systems, dynamic systems modeling, robustness of socioecolocgial systems
Carlos Castillo-Chavez	Professor (SHESC & MCMSC)	Mathematics and modeling of social landscapes of disease evolution and dispersal
José Lobo	Assoc. Res. Professor (SHESC & WPCSB)	Innovation, social networks, urban scaling & socioeconomics
Gerardo Chowell	Assistant Professor (SHESC)	Mathematical modeling of epidemiology for public health policy
Daniel Hruschka	Assistant Professor (SHESC)	Complex systems in human society and cultural transmission
Bert Höldobler	Professor (SoLS)	Behavioral ecology and evolution of social insects as CAS
Robert Page	Professor (SoLS)	Social evolution and complexity in insect systems
Manfred Laubichler	Professor (SoLS)	Gene networks, theoretical & evolutionary developmental biology
Jennifer Fewell	Professor (SoLS)	Behavioral ecology and evolution of social insects as CAS
Brian Smith	Professor (SoLS)	Computational models of neural networks to integrate information across molecular, neural and behavioral levels for understanding how animals learn relationships among stimuli
Sharon Crook	Associate Professor (SoLS/SMSS)	Mathematical models, analysis, and computer simulations to understand the biophysical mechanisms and algorithms underlying neural computation
Stephen Pratt	Assistant Professor (SoLS)	Group interactions and decision making using insects as model complex systems
Sudhir Kumar	Assistant Professor (SoLS)	Evolutionary bioinformatics and computer-based methods of analyzing genomes
Juergen Gadau	Associate Professor (SoLS)	How epigenetic and genetic variations in concert with expression differences generate qualitative and quantitative variations in the observed phenotypes
Juergen Liebig	Assistant Professor (SoLS)	Evolution and maintenance of sociality and cooperation
Marco Herrera-Valdez	Assistant Professor (SoLS)	Modeling and analysis of dynamics in physiological systems at the cellular/molecular and network levels

Rachata Muneepeerakul	Assistant Professor (SoS/AMLSS)	Evolutionary-game-theoretic and complex-adaptive-system approaches for understanding and predict potential ecological outcomes under various environmental conditions
Polmnia Amazeen	Associate Professor (Psych)	Coordination as a complex dynamical system
William Griffin	Professor (SSFD)	Agent based models of micro-social interaction and behavioral dynamics
David Schaffer	Assistant Professor (SSFD)	Social network and human interaction
James Adams	Assistant Professor (SSFD)	Social network dynamics for information diffusion and the spread of diseases
Subrahjit Guhathakurta	Professor (SGSUP)	Urban modeling for international, economic, & environmental planning
Paul Torrens	Associate Professor (SGSUP)	GI Science, agent modeling, urban & behavioral geography, cybergeography
Erik Johnston	Assistant Professor (SPA)	Applying models and simulations to policy choice decisions
Hessam Sarjoughian	Associate Professor (SCI)	Modeling frameworks for composable and scaleable heterogeneous systems

E. Is there a graduate faculty structure for this concentration program that will differ from the original degree program graduate faculty structure (**for PhD programs only**)? If yes, please include the name of the graduate faculty group and whether they will participate in offering this concentration.

We have preliminary approval from the ASU Graduate College to create a Graduate Faculty in Complex Adaptive Systems Science to administer this proposed doctoral concentration, and to advise and evaluate students.

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5. Additional Material — Please attach any additional information that you feel relates to the proposed concentration.
(Please label accordingly, i.e., Appendix or Attachment A, B, etc.)

Approvals *(if the proposal submission involves multiple units, please include letters of support from those units)*

DEPARTMENT CHAIR
(Please print or type)

See attached letters from Alexandra Brewis Slade, Sander van der Leeuw, and Robert Page

9-Nov-10

SIGNATURE   DATE

DEAN (Please print or type)

SIGNATURE   DATE

The following section will be completed by the GC following the recommendations of faculty governance bodies.

UNIVERSITY VICE PROVOST AND DEAN OF THE GRADUATE COLLEGE

SIGNATURE   DATE

Please note: Proposals for new concentrations also require the review and recommendation of approval from the University Graduate Council, Curriculum and Academic Programs Committee (CAPC), the Academic Senate (Information item only), and the Office of the Provost before they can be put into operation.

The final approval notification will come from the Office of the Provost.

GF0809E-92

APPENDIX: Sample Curricular Structures for Students with Various Backgrounds

This concentration is designed to serve students with highly varied backgrounds in the social, life, and applied mathematical sciences. We are particularly sensitive to the likelihood of highly varied backgrounds in mathematics among students in social and life sciences, and varied background in social/life sciences among students in applied mathematics. For this reason, we have course requirements in relevant mathematics, modeling, and applied domains in social and life sciences.

We also envision different emphases among students in this concentration. At the outset, we can envision students with greater interest and expertise in the mathematical and theoretical aspects of complex adaptive systems science. These students would take more and more advanced courses in the math and mathematical modeling of CAS, and design their doctoral research in this direction. This might include (but would not necessarily be limited to) many students enrolled in the *AMLSS PhD program and some in the Biology and Sustainability PhD programs*. An example curriculum might include

- CASS math: AML598 (Theory of Games & Applications in Biology)
- CASS modeling: CES561 (Modeling and Simulation Theory)
- CASS applications: BIO591 (Topics in Mathematics for Life and Sustainability Science)
- Research
- Dissertation

Other students would have greater interest and expertise in applying concepts and methods in social and life sciences. These students would need a more basic understanding of the mathematics and would emphasize modeling technologies and framing social/life science issues in CAS terms. This might include (would not necessarily be limited to) many students in the *Anthropology, Environmental Social Science, and Global Health programs, and some in the Biology and Sustainability PhD programs*. An example curriculum might include:

- CASS math: ASM591 (Dynamic Modeling in Social and Ecological Systems)
- CASS modeling: PUP598 (Modeling and Simulating Urban Environments)
- CASS applications: PAF591 (Complexity in Public Policy)
- Research
- Dissertation

OR

- CASS math: AML591 (Probability Theory for Complex Systems)
- CASS modeling: AML591 (Agent Based Modeling)
- CASS applications: BIO522 (Populations: Evolutionary Ecology)
- Research
- Dissertation

By seeking to involve a wide range of students, it is also possible that some students who otherwise would be qualified and have a strong interest in CAS approaches might be sufficiently lacking in the background needed to be successful in this interdisciplinary program. In such cases, the student's committee may recommend one or more remedial programs that would give them the background to benefit from the concentration. Examples of such courses could include:

Remedial math (examples):

- Undergraduate calculus, taken for graduate credit as a Reading and Conference. For example, MAT251 (Calculus for Life Sciences)
- AML494 (Probability & Statistics for Life and Social Sciences)

  It is not likely that this would be needed for students enrolled in the AMLSS or Biology PhD programs

Enhancing Social Sciences Background (examples):

- ASB462 (Medical Anthropology: Culture and Health)
- ASB504 (Ethnic Relations)
- ASB510 (Health: Social and Biocultural Theories)
- ASB530 (Ecological Anthropology)
- ESS513 (Institutions)
- ESS591 (Institutions, Society, and the Environment)
- SSH514 (Urban and Environmental Health)

It is not likely that this would be needed for students enrolled in the Anthropology, Environmental Social Science, or Global Health PhD programs

Enhancing Life Sciences Background (examples):

- BIO 431 (Genes, Development, and Evolution)
- BIO436 (Sociobiology and Behavioral Ecology)
- BIO524 (Ecosystems)
- ANB602 (Current Issues in Animal Behavior)

It is not likely that this would be needed for students enrolled in the Biology or Sustainability PhD programs

ATTACHMENTS: Letters of Support from the Directors and Graduate Faculties of the School of Human Evolution and Social Change, School of Sustainability, and School of Life Sciences.

CLAS Dean Approval and CLAS Curriculum Committee/Senate Approvals

From: Linda Lederman [mailto:Linda.Lederman@asu.edu]
Sent: Tuesday, December 07, 2010 11:58 AM
To: curriculumplanning@asu.edu
Cc: Jenny Smith
Subject: FW: New Graduate Concentration in Complex Adaptive Systems Science

I approve. Thank you.

Linda Lederman

Linda Costigan Lederman, Ph.D.
Dean of Social Sciences &
Professor of Human Communication, Hugh Downs School of Human Communication
College of Liberal Arts and Sciences
Arizona State University
PO Box 876505
Tempe, AZ 85287 USA
Voice: 480-965-0668 Fax: 480-965-1093

ASU College of Liberal Arts and Sciences — *Transforming learning, discovery and lives*

From: Jenny Smith
Sent: Tuesday, December 07, 2010 11:36 AM
To: Linda Lederman
Cc: Kacie McKay
Subject: New Graduate Concentration in Complex Adaptive Systems Science

Linda,

The CLAS Curriculum Committee and Senate have approved the attached proposal for a new graduate concentration in Complex Adaptive Systems Science. Please forward the proposal with your approval to curriculumplanning@asu.edu

Thank you,
Jenny

Memo

Date: November 5, 2010
To: Professor Michael Barton,
School of Human Evolution and Social Change
From: Sander van der Leeuw
Dean of the School of Sustainability
Director of the School of Human Evolution and Social Change
Co-Director, Complex Adaptive Systems Initiative
Re.: Graduate concentration in Complex Adaptive Systems

Dear Michael,

It is not often that I use all three current titles ASU has bestowed upon me, but this is an unusual occasion, as your initiative to put in place a graduate concentration in Complex Adaptive Systems actually crosses all three these responsibilities.

I am writing you to confirm that, in both my roles as Dean of the School of Sustainability and that of Director of the School of Human Evolution and Social Change, I not only approve, but laud the initiative of creating a concentration in Complex Adaptive Systems Science, and will be very happy to see the students in both schools take this concentration as part of the PhD in Sustainability, the PhD in Anthropology, PhD in Environmental Social Science, PhD in Global Health, and the PhD in Applied Mathematics for the Life and Social Sciences.

In my role as director of the CASI initiative, I congratulate you with doing this. It is clear that our current, essentially still reductionist, way of doing science is insufficient to deal with the challenges that we are facing in our global society. We urgently need new ways to think about the latter, and in particular ways that can study emergent behavior in many-dimensional systems. CAS is one such approach, and it is wonderful to see that we will now be able to begin training our students in this domain.

Sander van der Leeuw

ASU ARIZONA STATE UNIVERSITY

COLLEGE OF LIBERAL ARTS
AND SCIENCES
SCHOOL OF HUMAN EVOLUTION
AND SOCIAL CHANGE

MAIN CAMPUS
PO BOX 872402
TEMPE, AZ 85287-2402

TELEPHONE
(480) 965-6213
FACSIMILE
(480) 965-7671

November 5, 2010

Dr Michael Barton

Director, CBSC

Dear Michael,

Our school is pleased to support the new graduate concentration in complex adaptive systems. We will be delighted to open seats to concentration students in all our relevant courses. To allow students in the concentration to complete PhD degree requirements in a timely fashion, we are also happy to consider CAS concentration courses as counting as acceptable electives in SHESC PhD programs of study (subject of course to assent of students' major professors). We also will be delighted if faculty in our school decide to become members of the graduate faculty administering this innovative and important program.

Sincerely,

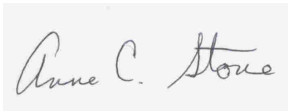Alexandra Brewis Slade.
Executive Director.

Dr. Michael Barton
Professor
Director, Center for Social Dynamics & Complexity
Arizona State University

January 25, 2011

Dear Michael:

I am writing to inform you of the SHESC graduate committee's unanimous support of the interdisciplinary graduate concentration for complex adaptive systems science. As a concentration, it does not require any new courses or any changes to existing curriculum requirements, and it is likely to be of interest to the graduate students in all four of our Ph.D. programs. Please contact me if you have any questions.

Sincerely,

Anne C. Stone, Ph.D.
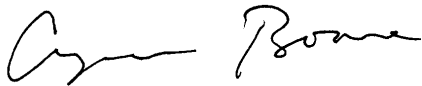Professor and Director of Graduate Studies

February 2, 2011

Professor Michael Barton
School of Human Evolution and Social Change
Arizona State University

Re: PhD Concentration in Complex Adaptive Systems Science (CASS)

Dear Professor Barton:

This letter is to confirm that the Ph.D. program in Sustainability will offer the Ph.D. concentration in Complex Adaptive Systems Science (CASS) pending final university approval of the concentration. Understanding and modeling complex adaptive systems in order to guide decisions towards desirable social and environmental outcomes is fundamental to sustainability science. The faculty and PhD students in the School of Sustainability are pleased to participate in the CASS concentration, and look forward to this and other opportunities for collaboration.

Sincerely,

Christopher Boone
Associate Dean for Education

Dr. Michael Barton   November 7, 2010
Director, Center for Social Dynamics & Complexity
Arizona State University

Dear Michael,

The School of Life Sciences agrees to participate in the proposed doctoral concentration in complex adaptive systems science.

Sincerely,

Robert E. Page, Jr.

Robert E. Page, Jr.
Dean and Foundation Professor
School of Life Sciences
Arizona State University

Dr. Michael Barton
Professor
Director, Center for Social Dynamics & Complexity
Arizona State University

February,3rd 2011

Dear Michael:

      I am writing to inform you that SOLS supports the formation of the interdisciplinary graduate concentration for complex adaptive systems science. As a concentration, it does not require any new courses or any changes to existing curriculum requirements, and it is likely to be of interest to graduate students in SOLS. Please contact me if you have any questions.

Sincerely,

(Jürgen Gadau)

MAIN CAMPUS
Dr. Jürgen Gadau
Associate Dean for Graduate Studies/SOLS
Associate Professor
College of Liberal Arts and Sciences
School of Life Sciences
PO Box 874501, Tempe, AZ 85287-4501
(480) 965-0803 Fax: (480) 965-6899