ESTABLISHING GRADUATE CERTIFICATES
ARIZONA STATE UNIVERSITY
GRADUATE COLLEGE

This form should be used by programs seeking to establish a new graduate certificate. All sections should be completed. Current graduate certificate guidelines may be found at http://graduate.asu.edu/faculty_staff/policies/other_opportunities.

The graduate certificate is a programmatic or linked series of courses in a single field or one that crosses disciplinary boundaries. The graduate certificate facilitates professional growth for people who already hold the baccalaureate degree and may be freestanding or linked to a degree program. The virtue of the graduate certificate is that it enables the university to respond to societal needs and promotes university interaction with corporate, industrial, and professional communities.

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

Please type.

Contact Name(s): **Michael Barton**	**Contact Phone(s): 965-6262**
College: N/A	
School: School of Sustainability	
Name of proposed Certificate: Graduate Certificate in Complex Adaptive Systems Science (CASS)	
Requested Effective Term and Year: (*e.g. Spring 2012*) **Fall 2013**	
Do Not Fill in this information: Office Use Only **CIP Code:**	

1. OVERVIEW. Below, please provide a brief overview of the certificate, including the rationale and need for the program, potential size and nature of the target audience, information on comparable programs (at ASU and/or peer institutions), how this program would relate to existing programs at ASU, and any additional appropriate information.

We propose to create a new interdisciplinary graduate that helps train 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. This concentration is designed to be complementary and closely linked to a recently approved and initiated interdisciplinary Doctoral Concentration in CASS

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.

2. ADMINISTRATION AND RESOURCES

A. How will the proposed certificate be administered (including recommendations for admissions, student advisement, retention etc.)? Describe the administering body in detail, especially if the proposed certificate is

part of a larger interdisciplinary agenda. How will the graduate support staff for this proposed certificate program be met?

This is a companion program to the existing PhD concentration in CASS. It is designed for students who are unable to participate in the CASS doctoral concentration for programmatic reasons, but want to enhance their doctoral studies with structured training in CASS. This will extend CASS training to a wider disciplinary range of students beyond the programs participating in the concentration. Hence, it will be administered by the same CASS Graduate Faculty that administers the doctoral concentration. The CASS Graduate Faculty will review all recommendations for admission and serve on students' supervisory committees for advisement. The same graduate support staff will be used as with the CASS doctoral concentration.

B. What are the resource implications for the proposed certificate, including any projected budget needs? 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 certificate, 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 certificate program.

No new resources needed. The proposed certificate will be a companion program to the existing PhD concentration in CASS.

3. ADMISSIONS PROCEDURES AND CRITERIA

A. Admission criteria – Applicants must meet the admissions criteria for the Graduate College. Please also include any other additional admission requirements, e.g. type of undergraduate degree, minimum GPA, tests and/or entry-level skills that are required for this certificate program. (http://graduate.asu.edu/faculty_staff/policies/admissions)

All students must be enrolled and in good standing in an ASU doctoral program, or accepted into such a program for incoming students. They must submit a letter of application to the CASS Graduate Faculty, accompanied by a copy of their current transcript, and a letter of support from an ASU faculty member (for existing ASU students) or other faculty member (for incoming students).

B. Application Review Terms

Indicate all terms for which applications for admissions are accepted and the corresponding application deadline dates, if any:

To select desired box, place cursor on the left side of the box, right click mouse, select ***Properties***, under ***Default Value*** select ***Checked***, press ***OK*** and the desired box will be checked

☒ Fall Deadline (month/year): December 1

☐ Spring Deadline (month/year):

☐ Summer Deadline (month/year):

C. Projected annual admission/enrollment

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

Initially, we will aim for 5 students in the first year and no more than 10 in each subsequent year.

4. ACADEMIC REQUIREMENTS

A. Minimum credit hours required for certificate (15 credit hour minimum)

15

B. 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.

Variable. Currently, all relevant courses are offered face to face. However, some are transitioning into hybrid courses, and some may become completely online at some future date.

C. As applicable, please describe culminating experience required (e.g., internship, project, research paper, capstone course, etc.)

N/A

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

This is planned as a graduate certificate 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 certificate graduates.

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 diverse academic disciplines.

E. How will students be assessed and evaluated in achieving the knowledge, competencies, and skills outlined in 4.D. above? Examples of assessment methods can be found at (http://www.asu.edu/oue/assessment.html).

Because this is an interdisciplinary certificate for students in existing doctoral programs, students must first be assessed and evaluated according to the metrics of these programs. Additionally, their success in the certificate will be evaluated by two other metrics. The first 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.

Unlike the parallel concentration, however, the student is not required to apply CASS concepts and methods in his/her doctoral dissertation and have a chair/co-chair of his/her a supervisory committee who is a member of the CASS graduate faculty. However, all students in the certificate program must have at least one member of the CASS Graduate Faculty serving on their doctoral supervisory committees, and are strongly encouraged to apply CASS concepts and methods in their doctoral research.

F. Satisfactory student academic progress standards and guidelines (including any time limits for completion).

This is measured by academic progress standards in each student's home doctoral program, together with the assessment instruments in E above.

G. Will this proposed certificate program allow sharing of credit hours from another ASU degree program to be used as part of this certificate program? (Please note that a maximum of 9 hours taken as a non-degree student at ASU, including as a part of a certificate program, may be used towards a future graduate degree at ASU).

Yes

H. Below, please list all required and elective courses in the appropriate boxes (you may attach additional pages if necessary).

Please ensure that all *new core* course proposals have been submitted to the Provost's office through the Curriculum ChangeMaker online course proposal submission system. Please note: a minimum of 2/3 of the courses required for a graduate certificate must be at the 500-level or above.

Required Courses			**Credit Hours**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)**
ASM570	Fundamentals of CAS Science	No	**3**
	One course in mathematics of CASS *Choose from…*		
AML610	Topics in Applied Mathematics for the Life and Social Sciences	No	**3**
AML591	Probability Theory		
ASM591	Dynamic Modeling in Social and Ecological Systems		
	…or equivalent approved by CASS Graduate Faculty		
	One course in modeling CASS *Choose from…*		
AML612	Applied Mathematics for the Life and Social Sciences Modeling Seminar	No	**3**
AML591	Agent Based Modeling		
ASM591	Dynamic Modeling in Social and Ecological Systems		
PUP598	Modeling and Simulating Urban Environments		
CSE561	Modeling & Simulation Theory & Application		
PAF591	Introduction to Policy Informatics		
	…or equivalent approved by CASS Graduate Faculty		

ASM591/BIO 591 PAF591 SOS598 PSY576 PSY598 ANB602 BIO591 BIO522 BIO545	*<u>One</u> course in application of CASS approaches within discipline to be approved by student's supervisory committee* *Examples…* Readings in Complexity Complexity in Public Policy & Management Social Network Analysis Dynamical Systems 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	No	**3**
<u>Electives</u>			**<u>Credit Hours</u>**
(Prefix & Number)	*(Course Title)*	*(New Course?) Yes or No?*	**(Insert Section Sub-total)**
	Research or Reading & Conference with CASS faculty member		**3**
	`		
<u>Culminating Experience (if applicable)</u>			**<u>Credit Hours</u>** **(Insert Section Sub-total)**
Total required credit hours			**15**

5. PRIMARY FACULTY PARTICIPANTS - Please list all primary faculty participants for the proposed certificate, including home unit and title. You may attach additional pages if necessary. (**)

Name	**Home Unit**	**Title**
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 socio-ecological 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
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

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

6. REQUIRED SUPPORTING DOCUMENTS
(Please label accordingly, i.e., Appendix or Attachment A, B, etc.)

Please include the following with your proposal:

A. Sample plans of study for students in the proposed program

B. Statements of support from all deans and heads of impacted academic units

7. APPROVALS - If the proposal submission involves multiple units, please include letters of support from those units.

DEPARTMENT CHAIR or SCHOOL DIRECTOR (PRINT/TYPE)	
SIGNATURE	DATE

DEAN (PRINT/TYPE)	
Sander van der Leeuw, Dean, School of Sustainability	
SIGNATURE	DATE September 21, 2012

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

EXECUTIVE VICE PROVOST FOR ACADEMIC AFFAIRS AND DEAN OF THE GRADUATE COLLEGE	
SIGNATURE	DATE

Please note: Proposals for new certificates also require the review and recommendation of approval from the University Graduate Council, Curriculum and Academic Programs Committee (CAPC), the Academic Senate, 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.

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APPENDIX A: Sample Curricular Structures for Students with Various Backgrounds

This certificate is designed to serve students with highly varied backgrounds across diverse disciplines in the social and natural sciences. We are particularly sensitive to the likelihood of highly varied backgrounds in mathematics among students in social and life sciences, and varied backgrounds in social/life sciences among students in 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 seeking this certificate. 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 *PhD in AMLSS program and some in the PhD in Biology and PhD in Sustainability 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

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

OR

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

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 deficiency programs that would give them the background to benefit from the certificate. The academic unit representative will be responsible for monitoring this coursework. Examples of such courses could include:

Deficiency math (examples):

- Undergraduate calculus, taken for graduate credit as a Reading and Conference. For example,
- 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