

School of Planning  
Faculty of Environment  
University of Waterloo

## PLAN 474 - 674

### Introduction to Agent-Based Modelling

Winter, 2023

**Online Seminar: synchronous session – Tuesdays (1:30 – 2:50 PM EST)**

**Virtual Lab: synchronous session – Thursdays**

**Morning Lab: (10:30 – 11:30 PM EST)**

**Afternoon Lab: (01:30 – 02:30 PM EST)**

**Instructors:**

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E-mail is the best way to reach us — please put “ABM class-Winter 2023” in the subject header

Office Hours: By appointment

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## **COURSE OUTLINE**

### **Calendar Description**

Agent-based models are computational simulation models, applied in a wide range of disciplines across the social sciences, used to explore complex problems. This class provides an accessible introduction to agent/individual based models and the complex problems they are used to explore, with an emphasis on healthy cities applications.

**Prerequisite:** There are no prerequisites other than upper-division or graduate standing. However, students are expected to have a facility with basic mathematics and introductory statistics. No programming background is required.

**Expectations:** Students are expected to be self-motivated and able to follow a “flipped class” model, where course readings are completed, and online lectures viewed before class. You must obtain the text and complete the reading and required exercises.

## Introduction

Agent-based models are computational simulation models applied across the social sciences, and (as individual-based models) in the ecological sciences. These simulation models are used to explore complex problems that are beyond the limits of analytical mathematics. Often simple models are also developed as exploratory “tools to think with”. Classic agent-based models have been used to explore urban segregation, social imitation, formation of social networks, complex transportation problems, land markets, and predator-prey models, among other areas.

The course will use recorded lectures and supporting content from Bill Rand’s Complexity Explorer class (<https://www.complexityexplorer.org/courses/76-introduction-to-agent-based-modeling-summer-2017>). One supporting text will be required: “Agent-based and Individual-based Modeling: A Practical Introduction - Second Edition” by Railsback and Grimm (<http://www.railsback-grimm-abm-book.com>). The course will use NetLogo, a very simple programming language used successfully with primary school students. No background in programming is required.

We will follow a “flipped class” model, with students viewing lectures and completing readings before the seminars. The synchronous seminars will be used for class discussions, conceptual individual/group activities, group project planning, and general consultation. The online lab session will be used for simple lab/homework exercises, drawn primarily from the textbook and “learning NetLogo” tutorials (<https://ccl.northwestern.edu/netlogo/docs/>).

Students are expected to complete a final project exploring a specific research question using agent-based modeling. Graduate students will be required to incorporate a brief literature review. This is a group work, however, students who are developing models for their theses have the option to work individually.

Finally, we will supplement course content with guest lectures from scholars using agent-based modeling whenever the opportunity presents itself.

As this is the first time the class is taught online, we will evaluate the progression of course topics as the class, and we may adjust the schedule of the topics. We will not cover more material than is now listed on the course syllabus.

### LEARNING OUTCOMES

- Understanding the features of a complex system.
- Understanding the fundamentals of agent-based modeling.
- Gaining basic competence with the NetLogo programming language.
- Exploring and extending an agent-based model as applied to scientific research.
- Designing and carrying out a simple agent-based model.

### LEARNING MODES

#### 1. Tuesday Seminars: (attendance is required)

- While the seminars will be an opportunity for questions and discussions, the majority of class time will be active learning tasks, making use of the background readings/work you have done outside of class.

- The seminar will be used for Q and A, individual/group brainstorming exercises, and group design work for projects. The group project aims at learning to work in an interdisciplinary context while building leadership and collaboration skills.
- Groups will post their notes & findings on the relevant discussion forum at the end of the seminar.

## 2. Thursday Labs: (attendance is required)

- There are two lab sessions per week (morning and afternoon). Participants are required to choose one session at the beginning of the course and commit to attend the chosen lab session throughout the course duration.
- The lab session will focus on NetLogo. Ideally, you will be able to complete these and turn them in during lab time.
- The instructors will be there to help in the lab if need be. Discussion among classmates can be a very efficient method to complete lab work. Students are encouraged to work on the labs in groups, but each group member must write and upload their own code and written answers, as needed.

### **CAUTION/ENCOURAGEMENT**

A note by course author: Prof. D. Parker

*Many people are intimidated by a class focused on modeling and programming. Society has created a myth that programmers are a special breed of genius people, wearing t-shirts that say "You had me at Hello World," quirky and endowed with a special brilliance, coming out only at night and subsisting on a diet of skittles, Mountain Dew, and pizza.*

*This is a myth. Just like virtually anyone can learn math, virtually anyone can learn how to program. Most people even find it fun (more fun than math, even!). NeLogo was developed to be very accessible and user-friendly, and it's used with primary school students.*

*In the future, every student will learn basic programming in primary school, and the myth of the programmer will be debunked. Between then and now, don't be intimidated by a programming class. You can do it!*

**SEQUENCE OF TOPICS / SCHEDULE**

There may be minor adjustments in sequence and date. Students are responsible for all of the topics listed below. Sections in the text or readings that are not included in this list are not covered in the course classes and are not.

<b>Week</b>	<b>Date / Course Component</b>		<b>Topic / Required reading, online lecture, or lab work</b>	<b>Submission(s)</b>
Week 1	Jan. 10 <sup>th</sup>	NA	No Class	
	Jan. 12 <sup>th</sup>	First Class	Introduction & course logistics	
Week 2	Jan. 17 <sup>th</sup>	Seminar 01	Complex systems / Chapter 01 textbook + Lec. 1.1 – 1.5	
	Jan. 19 <sup>th</sup>	Lab 01	NetLogo tutorials 1-3	Individual post: Introduce yourself
Week 3	Jan. 24 <sup>th</sup>	Seminar 02	Complex system case studies	Deducing research questions exercise
	Jan. 26 <sup>th</sup>	Lab 02	Chapter 2: Mushroom hunt model	Discussion Post: Case study
Week 4	Jan. 31 <sup>st</sup>	Seminar 03	Research question & Purpose / Lit. review on case study (Grade students) + Lec. 2.1 - 2.3	Mushroom hunt model
	Feb. 2 <sup>nd</sup>	Lab 03	Chapter 4: Butterfly model (1)	Discussion Post: Research question + lit. Review for Grad students
Week 5	Feb. 7 <sup>th</sup>	Seminar 04	Model Entities / State variables / Scales / Chapter 3	Butterfly model (1)
	Feb. 9 <sup>th</sup>	Lab 04	Chapter 5: Butterfly model (2) + Lec. 3	Discussion Post: Model components
Week 6	Feb. 14 <sup>th</sup>	Seminar 05	Visual ODD exercise	
	Feb. 16 <sup>th</sup>	Lab 05	Chapter 6: Finding errors	Butterfly model (2)

Week 7	Feb. 21 <sup>st</sup>	<i>No lecture or tutorials – Reading week</i>		
	Feb. 23 <sup>rd</sup>			
Week 8	Feb. 28 <sup>th</sup>	Seminar 06	Design concepts / Selection of chapters (7-16) based on groups	Group presentation: Design concepts
	Mar. 2 <sup>nd</sup>	Lab 06	Design concepts / Selection of chapters (7-16) based on groups	Group presentation: Design concepts
Week 9	Mar. 7 <sup>th</sup>	Seminar 07	Processes & sub models/ Chapters 18 - 19	Group presentation: Design concepts
	Mar. 9 <sup>th</sup>	Lab 07	Chapter 8: Designing experiments	Submit Visual ODD
Week 10	Mar. 14 <sup>th</sup>	Seminar 08	Parameterization & Calibration / Chapter 20	
	Mar. 16 <sup>th</sup>	Lab 08	Lec. 4.1- 4.2 & 5.1-5.3 / Project: Initial coding	Submit Design concepts and model details
Week 11	Mar. 21 <sup>st</sup>	Seminar 09	Model Analysis / Chapter 22	
	Mar. 23 <sup>rd</sup>	Lab 09	Lec. 7.1-7.2 / Project: Code refinement & debugging	
Week 12	Mar. 28 <sup>th</sup>	Seminar 10	Results Interpretation	
	Mar. 30 <sup>th</sup>	Lab 10	Lec. 6 / Project: Running model experiments + reporting outputs	
Week 13	Apr. 4 <sup>th</sup>	Seminar 11	Draft project presentation	Submit Draft presentation.
	Apr. 6 <sup>th</sup>	Lab 11	Findings & write-up.	
Week 14	Apr. 10 <sup>th</sup>	Seminar 12	Final project / Group Presentation	Final project oral presentation.
	Apr. 12 <sup>th</sup>		NA	
Week 15	Apr. 17 <sup>th</sup>	Seminar	NA	
	Apr. 19 <sup>th</sup>		Final project - Submission	
*NOTE:				
<ul style="list-style-type: none"> <li>All readings are to be completed before Tuesday's seminars.</li> </ul>				

- Guest lectures will be announced as the term progresses.
- Grading breakdown & weights will be announced on LEARN.
- Marks for discussion posts will depend on completing all of these activities (i.e., completion of all activities equals full marks).
- There may be minor adjustments in sequence and date.

## FINAL EXAM

No Final examination. The Final project report serves the role of the take-home exam.

## TEXTS / MATERIALS

### Required Text

1. "Agent-based and Individual-based Modeling: A Practical Introduction" Second Edition - by Steven F. Railsback and Volker Grimm (<http://www.railsback-grimm-abm-book.com>).
2. Supplementary (optional) readings will be filled in as the term progresses.

The text should be available at the UofW bookstore or online. You must have access to any.

### Required Lectures

1. Bill Rand's Complexity Explorer class (<https://www.complexityexplorer.org/courses/76-introduction-to-agent-based-modeling-summer-2017>) (free!)

## SPECIAL REQUIREMENTS IN THIS COURSE

### Computer Use

*Students are **required** to complete their assignments using a personal computer.*

*Students must download and install the NetLogo software on their personal computer. U of W students may seek assistance from the MAD helpdesk if needed.*

*To avoid discrepancies, make sure to download NetLogo version 6.0.4 since the textbook is current with this version only, which was released in 2018.*

*Students are expected to have experience with some sort of software (excel or a statistical package) for downloading and analyzing the model output.*

## STUDENT EVALUATION

The instructor determines the content and establishes the grading rules for all assignments, mid term (if any), final examination(s), and any essays or projects.

<b>Course Component</b>	<b>Percentage</b>
<i>Lab reports (individual submissions)</i>	<i>20%</i>
<i>Attendance, Seminar discussions, &amp; Discussion posts</i>	<i>30%</i>
<i>Final project</i>	<i>50%</i>

***Extensions of due dates will be made only if consensus exists in the course. Any updated due dates will appear on the course outline. If the instructor wishes to have freedom to appropriately adjust final student grades, an appropriate statement must be made.***

*When determining a student's final grade in the course, the instructor will examine the record of each individual student's achievement; the final grade may be adjusted to take into account, extenuating and compassionate circumstances.*

### **Requirements, Grade Penalties and Special Considerations:**

#### **Lab submissions:**

Students will be required to write short lab reports for exercises primarily drawn from the textbook. Full details will be provided on LEARN. Labs are designed to be a learning experience, and reports will be marked accordingly. Feedback and/or answer keys (if any) will be announced on LEARN. Lab reports are due on LEARN at 12:00 PM on the next seminar day following the lab session. Provided all lab reports are completed with a passing mark (50% or higher), the lowest lab mark will be dropped.

#### **Seminar discussions/Group work posts:**

Students are expected to attend these sessions and actively participate. Early in the term, students will be asked to post responses to some brainstorming questions on course forums. As project interests emerge, the instructor will form smaller groups of students with similar interests for project discussions. Marks for this section will depend on completing all of these activities (i.e. completion of all activities equals full marks)

#### **Final Projects:**

Each group (2-3 students) will complete a project that includes the following components:

- Identification of a complex systems research question of interest
- Design of a model or model modification and experiments appropriate to answer the question
- A series of computational experiments and analysis of output to explore the question
- A short oral presentation to the class (with a model demo and/or slides) at the end of term
- A written report, due in the electronic dropboxes.
- LATE PROJECT REPORTS CAN NOT BE ACCEPTED—PLEASE PLAN ACCORDINGLY
  - Each group will work with the instructor to define an appropriate topic and scope for their project. Groups might extend and/or modify an existing NetLogo model.
  - Students considering this work as part of their thesis are allowed to work individually.
  - Full details of this assignment, including a breakdown of marking, will be provided on LEARN.

**Referencing / Citation:** The School of Planning has adopted a single standard referencing system for all papers and assignments submitted in Planning courses. The format is the APA (American Psychological Association) style. The complete style outline can be found in the Publication Manual of the American Psychological Association, located in the reference section in Dana Porter Library, or on sale in the Book Store. You may also want to consult the following web resources:

- APA Frequently Asked Questions - <http://www.apastyle.org/learn/faqs>
- Purdue University Online Writing Lab (OWL): <https://owl.english.purdue.edu>
- University of Wisconsin-Madison Writing Centre: <http://www.writing.wisc.edu>

**Lateness penalty:** All assignments are due on the date set by the instructor. Students may use a bank of 3 "grace days", which will allow them to submit assignment(s) up to 72-hours late with no late penalty and no questions asked. Students do not need to ask the instructor in advance to use these grace days. They may use all of their grace hours on a single assignment, or they may spread them out across all assignments. If a student submits later than that or already used their "grace days" on a previous assignment, a 10% penalty is incurred for each 24-hour period that the assignment is late. A student's assignment more than seven days business days late will not be accepted, and a grade of zero will be recorded for that assignment.

Students are encouraged to request extensions at least one week in advance when they foresee a challenge with completing an assignment (e.g., competing deadlines, job interviews, religious observances, etc.). Students should also contact the instructor to request an accommodation for illness and/or other personal circumstances.

**Note:** Requests for exemptions or compassionate considerations are to be discussed with the instructor in advance or as soon as possible. If you are ill or have a personal emergency, contact the instructor, and they will follow the university's standard procedures to adjust your requirements/due dates. Do not feel that you should come to class under these circumstances.

### **ASSIGNMENT SCREENING**

Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Please refer to University Policy below for more information on Turnitin.

### **ADMINISTRATIVE POLICY**

**Intellectual Property:** For further information on IP related to teaching, please see [https://uwaterloo.ca/legal-and-immigration-services/sites/ca.legal-and-immigration-services/files/uploads/files/volume\\_1\\_issue\\_3\\_winter\\_2018.pdf](https://uwaterloo.ca/legal-and-immigration-services/sites/ca.legal-and-immigration-services/files/uploads/files/volume_1_issue_3_winter_2018.pdf) and the Guidelines for Faculty, Staff and Students Entering Relationships with External Organizations Offering Access to Course Materials, <https://uwaterloo.ca/secretariat/faculty-staff-and-students-entering-relationships-external>. The following text is recommended:

Students should be aware that this course contains the intellectual property of their instructor, TA, and/or the University of Waterloo. Intellectual property includes items such as:-Lecture content, spoken and written (and any audio/video recording thereof);-Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides);-Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and-Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein, are used to enhance a student's educational experience. However, sharing this intellectual property without the intellectual property owner's permission is a violation of intellectual property rights. For this reason, it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository).

Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain



materials. However, doing so without expressed permission is considered a violation of intellectual property rights.

Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online. The intellectual property rights owner deserves to know (and may have already given their consent).

**Research Ethics:** The University of Waterloo requires all research conducted by its students, staff, and faculty which involves humans as participants to undergo prior ethics review and clearance through the Director, Office of Human Research and Animal Care (Office). The ethics review and clearance processes are intended to ensure that projects comply with the Office's Guidelines for Research with Human Participants (Guidelines) as well as those of provincial and federal agencies, and that the safety, rights and welfare of participants are adequately protected. The Guidelines inform researchers about ethical issues and procedures which are of concern when conducting research with humans (e.g. confidentiality, risks and benefits, informed consent process, etc.). If the development of your research proposal consists of research that involves humans as participants, the please contact the course instructor for guidance and see: <https://uwaterloo.ca/research/office-research-ethics>

**Anti-racism Statement:** The University of Waterloo does not tolerate racism or any other form of discrimination and expects campus community members to contribute to a culture where all members feel safe and valued. Any member of the campus community who has experienced racism or discrimination at the University is encouraged to seek guidance from the Office of Equity, Diversity, Inclusion & Anti-racism (EDI-R) via email at [equity@uwaterloo.ca](mailto:equity@uwaterloo.ca) or through their website: [uwaterloo.ca/human-rights-equity-inclusion/about/equity-office3](https://uwaterloo.ca/human-rights-equity-inclusion/about/equity-office3)

**Mental Health:** The University of Waterloo, the Faculty of Environment and our Departments/Schools consider students' well-being to be extremely important. We recognize that throughout the term students may face health challenges - physical and / or emotional. Please note that help is available. Mental health is a serious issue for everyone and can affect your ability to do your best work. Counselling Services <https://uwaterloo.ca/campus-wellness/> is an inclusive, non-judgmental, and confidential space for anyone to seek support. They offer confidential counselling for a variety of areas including anxiety, stress management, depression, grief, substance use, sexuality, relationship issues, and much more.

All students are encouraged to download the WatSAFE app which is available free through the google and iOS app stores. The WatSAFE app provides on- and off-campus contacts for students in distress, including international students, and other information related to campus safety and security.

**Religious Observances:** Students need to inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments.

**Unclaimed assignments:** Unclaimed paper assignments are normally retained for at least one month after term grades become official in quest. After that time, they will be destroyed in compliance with UW's confidential shredding procedures

**Communications with Instructor and Teaching Assistants:** All communication with students must be through either the student's University of Waterloo email account or via LEARN. If a student emails the instructor or TA from a personal account they will be requested to resend the email using their personal University of Waterloo email account

**Recording lecture:** Use of recording devices during lectures is only allowed with explicit permission of the instructor of the course. If allowed, video recordings may only include images of the instructor and not fellow classmates. Posting of videos or links to the video to any website, including but not limited to social media sites such as: facebook, twitter, etc., is strictly prohibited

## UNIVERSITY POLICY

**Academic integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check the Office of Academic Integrity for more information.]

**Grievance:** A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

**Discipline:** A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for their actions. [Check the Office of Academic Integrity for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties.

**Appeals:** A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72, Student Appeals.

**Note for students with disabilities:** AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

**Turnitin.com:** Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.