



the **uva** bay game

The U.Va. Bay Game Team

In just six months a team of University of Virginia faculty members and students, working closely with consultant Chris Soderquist, developed and tested the first version of the [U.Va. Bay Game](#), an innovative agent-based simulation that allows students to play the roles of farmers, watermen, developers, and local policy makers in the 6-state Bay watershed and assess the impact of their behavior on each other and on watershed health.

The faculty team includes representatives from 10 departments in 7 academic units: Project leader Gerry Learmonth (Engineering and Applied Science), Mark White (Commerce), Dave Smith (Environmental Sciences) Bill Sherman (Architecture), Winston Lung, Paxton Marshall (Engineering and Applied Science), Jon Cannon, Leon Szeptycki (Law), Bob Landel (Darden), and Dick Guerrant (Medicine).

Five graduate students from Gerry Learmonth's spring systems integration seminar developed and assembled the Game components: J. Barrett Strausser, Jie Xing, Michael Purvis, Zhenyu Guo, Matthew White.

A student advisory group assisted in Game planning and milestone evaluations: Elizabeth Tilton, Gregory Tilton, Carter Ware, Lane Ware, Michelle Henry, Jenny Rheuban, Emma Siegfried, Andrew Clark, Brandon Conroy, Matthew Smith.

[144 U.VA. students](#) tested the Game.

Bill Sherman (Architecture) designed the Game logo and T-shirt.

The U.Va. Bay Game is sponsored by the Office of the Vice President for Research. The U.Va. Bay Game aligns with current institutional planning for research, research-based learning, and translational projects that provide innovative solutions to urgent global problems. Vice President for Research Tom Skalak encouraged the U.Va. Sustainability Leadership Group to develop the Game and participated in its development; Associate Vice President for Research Jeffrey Plank managed Game development.

Game Facts

- The U.Va. Bay Game is a large-scale simulation game (sim/game) that combines elements of a highly integrated model of the Chesapeake Bay Watershed using systems dynamics modeling techniques and an interactive game interface where players assume roles and play the game according to those roles.
 - The systems dynamics modeling was written in STELLA, a systems dynamics modeling software package from isee systems, Inc., Lebanon, New Hampshire.
 - The STELLA coding was accomplished by consultant Chris Soderquist (Pontifex)
 - The model currently contains 43,023 equations.
 - The game front-end was developed using the Forio package from Forio, Inc., San Francisco.
 - The Forio development (the student player interfaces) were developed by a team of five Systems and Information Engineering graduate students.
 - The entire integrated software package was hosted on a virtual server at the McIntire School of Commerce.
- During the week of April 6-10, an integration test of this sim/game was conducted to test the sim/game rigorously in a “live” environment.
- The test achieved both successful technical results and realistic environmental outcomes as a result of the player’s participation.
- The Chesapeake Bay Watershed is represented in the sim/game as a collection of seven smaller watershed regions and the Bay itself divided into a north and a south region.
- The seven watersheds include:
 - Susquehanna
 - Patuxent
 - Eastern Shore
 - Potomac
 - Rappahannock
 - York
 - James
- Each of these smaller watersheds contained an agricultural sector and a land development sector as well as general public sector.
 - The agricultural sectors contained simulated farms in proportion to the actual number of farms in those watersheds, including the number of acres in production.

- In total, the sim/game modeled approximately 64,000 farms throughout the Chesapeake Bay Watershed with 35 “live” players making farming decisions while the remainder of the farms were simulated (with 5 players as farmers in each of the 7 watersheds).
- The land development sector in each of the watershed regions was represented by the number of urban/residential acres and acres which were able to be converted from agriculture or forest to development, that is, infill acres and greenfield acres. Land development players engaged in making decisions to buy and sell land as well as choices to develop property they owned using conventional practices or sustainable practices. There were 35 “live” players engaged in land development (5 in each of the 7 regions).
- In each region, there were 35 “citizens” who represented public opinion by entering their feelings about the economy, the environment, and their perceived quality of life in the region. These opinions were available to other decision-makers (players) to factor into their game decisions.
- Lastly, there were 31 watermen on the Bay (16 north and 15 south) engaged in crab fishing. These watermen had decisions related to the method of harvesting (dredging or potting) and the length of the season during which they harvested. They also had the opportunity to invest in a new boat which would increase their efficiency weighed against the required cash investment in the boat.
- Additionally, three players made agricultural policy decisions: three players made land use policy decisions, and two players made decisions regarding the crab industry on the Bay. In effect, these policy-makers could incentivize or curtail the other players’ decision-making through their imposition of policies on their respective areas of authority.
- Faculty members from 7 U.Va. academic units participated in game development (Architecture, Arts & Sciences, Commerce, Darden, Engineering and Applied Science, Law, Medicine).
- 144 U.Va. undergraduate students/players participated in the week-long test of the U.Va. Bay Game.
- Game operation
 - A total of ten rounds of the game were played over four days.
 - Each round represented two years of simulated time beginning in 2000 and ending in 2020 (the underlying models stepped through time on a quarterly basis).
 - Decisions were entered by each player at each round and the players saw the results from the previous round.

- Players saw their own decisions, the results of the decisions in their own region, and selected outcomes from the whole region, like unemployment rates and the overall health of the Bay.
 - The measure of the Bay's health was represented by a single variable—the size of the anoxic region as determined by the flow of nitrogen and phosphorous into the Bay from agriculture and development activities. This variable was tuned to the actual size of the region in 2000 and the forecast size of the region in 2008.
 - Many students playing farmer roles chose to move from conventional high yield farming practices to organic and polyculture practices during game operation.
 - Likewise, students playing land developer roles chose sustainable development practices and infill development over conventional development of Greenfield acres.
 - The result of these decisions was a significant decrease in the nitrogen and phosphorous inflow to the Bay with a corresponding decrease in anoxia and a growth in the crab population.
 - The watermen then enjoyed outstanding crab harvests while the crab population grew reversing a declining trend.
 - A small caveat—the student game players were not representative of the agricultural and land development communities. Because the students lacked experience as farmers, their unbridled enthusiasm for “doing the right thing” for the Bay perhaps was at odds with the need to make a living in these roles—except of course the watermen who were very successful at crabbing!
- The future
 - The faculty and the student players created an extensive list of Bay Game improvements and extensions.
 - These will be prioritized—in consultation with actual stakeholders—and many will be incorporated into the simulation/game over the summer with the goal of a richer tool for research, learning, and outreach at the beginning of the fall semester and through the coming academic year.
 - We also plan to share the U.Va. Bay Game with state and federal agencies, stakeholder organizations, and conservation NGOs. We anticipate that the Bay Game will become a useful and important tool in developing solutions for Bay conservation.

Contacts for the U.Va. Bay Game

Gerard Learmonth, Research Assoc. Professor, Dept of Systems & Information Engineering

Phone: 434-982-2100

Email: learmonth@virginia.edu

Learmonth led development of the U.Va. Bay Game.

Mark White, Associate Professor, School of Commerce

Phone: 434-924-7365

Email: maw3u@Virginia.EDU

White provided economic expertise in the development of the game. His students tested the game during the week of April 6-10.

David Smith, Professor, Department of Environmental Sciences

Phone: 434-924-0561

Email: des3e@Virginia.EDU

Smith helped develop the watermen role with scientific information about the Bay. Smith led a relevant J-term undergraduate class this year, "Chesapeake Bay Ecology and Conservation." The Bay Game student advisory group included some of Smith's J-term class students; some of Smith's oceanography students took part in game testing.

Bill Sherman, Associate Dean, School of Architecture

Phone: 434-924-7592

Email: sherman@virginia.edu

Sherman provided land-use information for the game, including farmer data and designed the game logo and t-shirt.

Thomas Skalak, Vice President for Research

Phone: 434-243-8000

Email: tcs4z@Virginia.EDU

Skalak was one of the founders of the game and his office sponsored game development.

Jeffrey Plank, Associate Vice President for Research

Phone: 434-924-6901

Email: jplank@virginia.edu

Plank recruited faculty participants and managed game development.