

# Playing with nature: social-ecological games and modelling

17 Apr 2023

# Human decision-making and SDGs

Need to understand how people make decisions in complex social-ecological systems (SDGs 3, 7, 13, 15, & 16)

- ▶ ecosystem management<sup>1</sup>
- ▶ biodiversity loss<sup>2</sup>
- ▶ food security<sup>3</sup>
- ▶ energy management<sup>4</sup>

Integrate ecological, environmental, and social dynamics



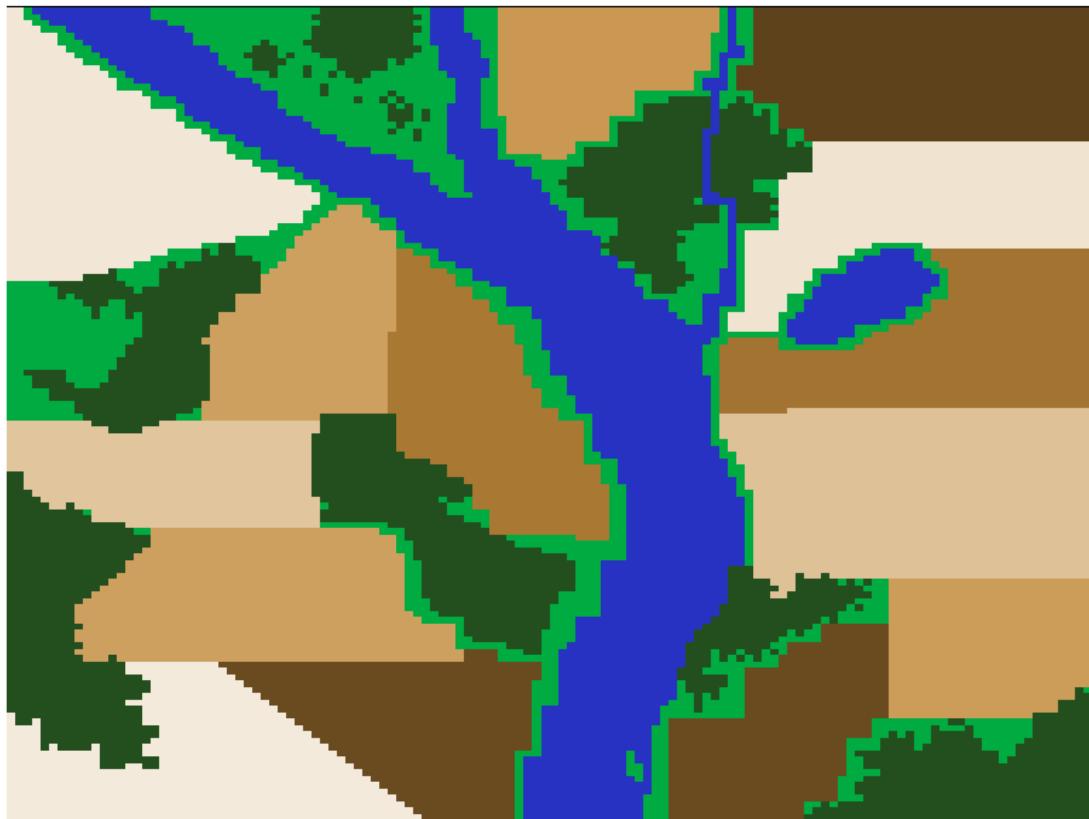
<sup>1</sup>Defries, R & H Nagendra. 2017. *Science* 356:265-270.

<sup>2</sup>Mason, T. H. et al. 2018. *Conserv. Lett.* 11:1-9.

<sup>3</sup>Gould, F, et al. 2018. *Science* 360:728-732.

<sup>4</sup>Thollander, P, et al. 2019. *Sustainability* 11:1-11.

# Complex landscapes in agent-based models



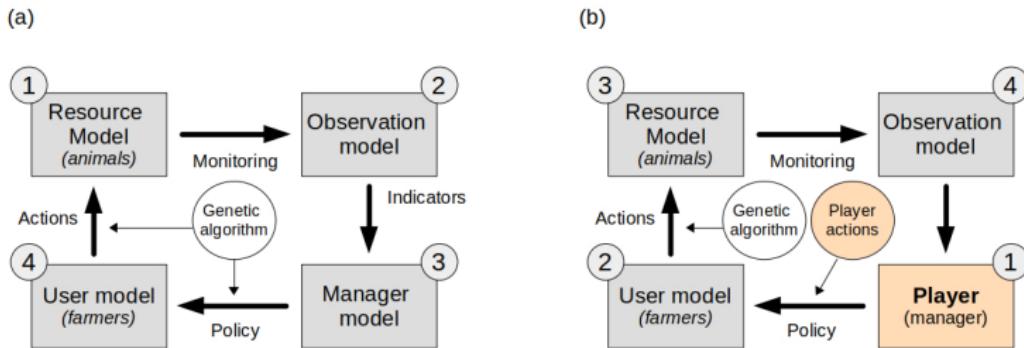
<sup>1</sup>Duthie, AB, et al. 2022. *bioRxiv*. DOI: 10.1101/2022.08.22.504740.

<https://bradduthie.github.io/resevol/>

# Gamifying GMSE (Animal and Farm)

Create a game using the modelling package

Substitute model decision-making with real players<sup>1</sup>

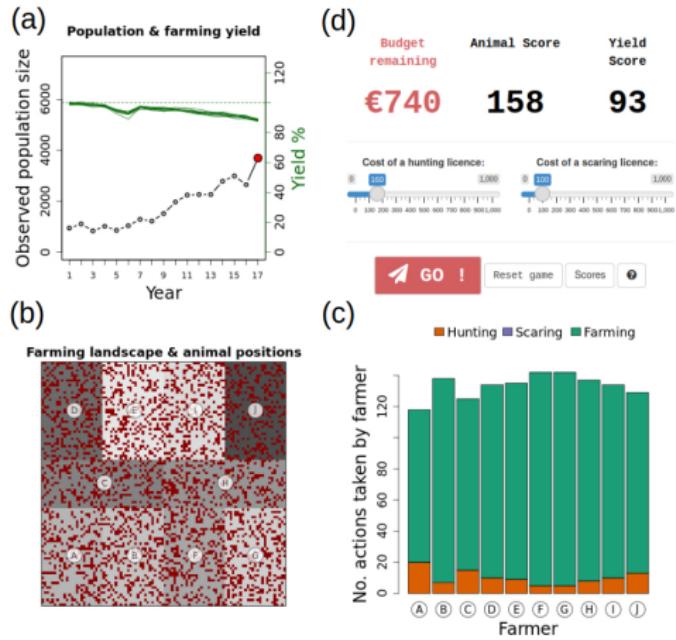


Collect data to see how people play

<sup>1</sup>Minderman, J, et al. 2021. *bioRxiv*. DOI: 10.1101/2021.09.23.461497

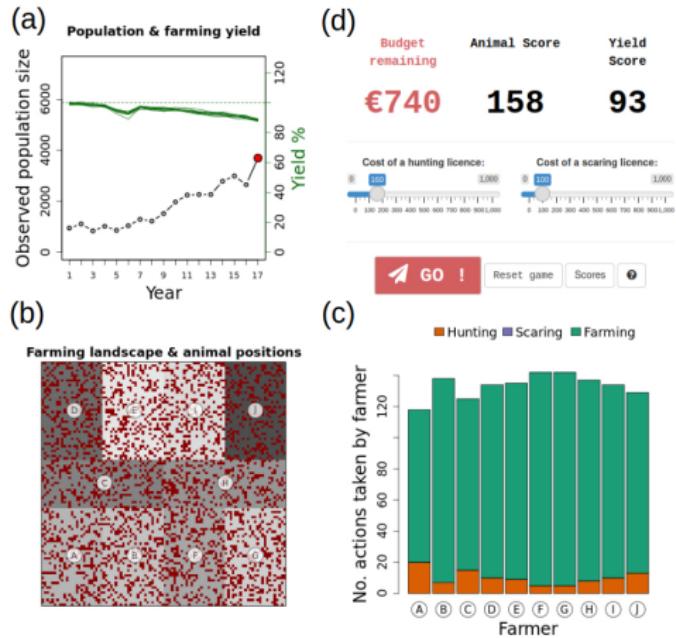
# Gamifying GMSE (Animal and Farm)

- ▶ Players use sliders to set policy
- ▶ Players gave feedback on game



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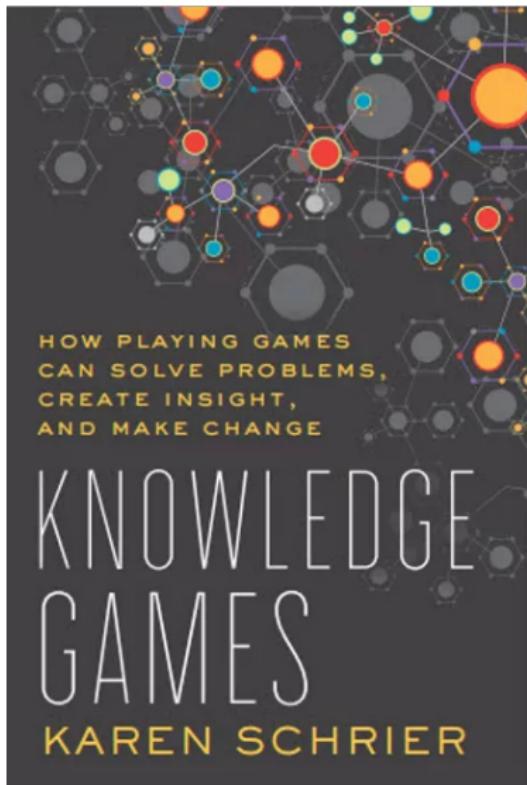


Game feedback is model feedback<sup>1</sup>

<sup>1</sup>Minderman, J, et al. 2021. *bioRxiv*. DOI: 10.1101/2021.09.23.461497

## Knowledge games

**Knowledge games** “seek to invent, create, and synthesise new understandings of the world, solve real-world problems big and small, and help us reconsider, reframe, and reflect on humanity and our universe.” [1]



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<sup>1</sup>Schrier, K. 2016. *Knowledge games: How playing games can solve problems, create insight, and make change*. John Hopkins University Press.

# Social simulation games are very popular

Decision-making in complex social-ecological systems is the focus of many highly popular games<sup>1</sup>.

- ▶ **Farmville**

- ▶ 80 million players
- ▶ Diverse player base<sup>2,3</sup>

- ▶ **SimCity**

- ▶ 1989 to present
- ▶ Millions of copies sold

People invest a lot in these games and take their decisions seriously<sup>1,4</sup>.



<sup>1</sup>Duthie et al. 2021. *Conserv. Biol.* 35:1051-1053.

<sup>2</sup>ESA. Essential Facts 2019. *Entertainment Software Association*.

<sup>3</sup>Berry, N. Facebook Casual Game Demographics.

(<http://www.datagenetics.com/blog/december12010/>), accessed 2020-11-17.

<sup>4</sup>Yee, N. 2006. *Avatars at work and play*. Pp 187-207. Springer.

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# Social simulation games are very popular



<sup>1</sup>Lane, R. 2018. The Guardian  
(<https://www.theguardian.com/games/2018/jul/24/meet-the-real-life-farmers-who-play-farming-simulator>), accessed 2020-10-25.

# Overlap between games and agent-based models



<sup>1</sup>Duthie, AB, et al. 2022. *bioRxiv*. DOI: 10.1101/2022.08.22.504740.

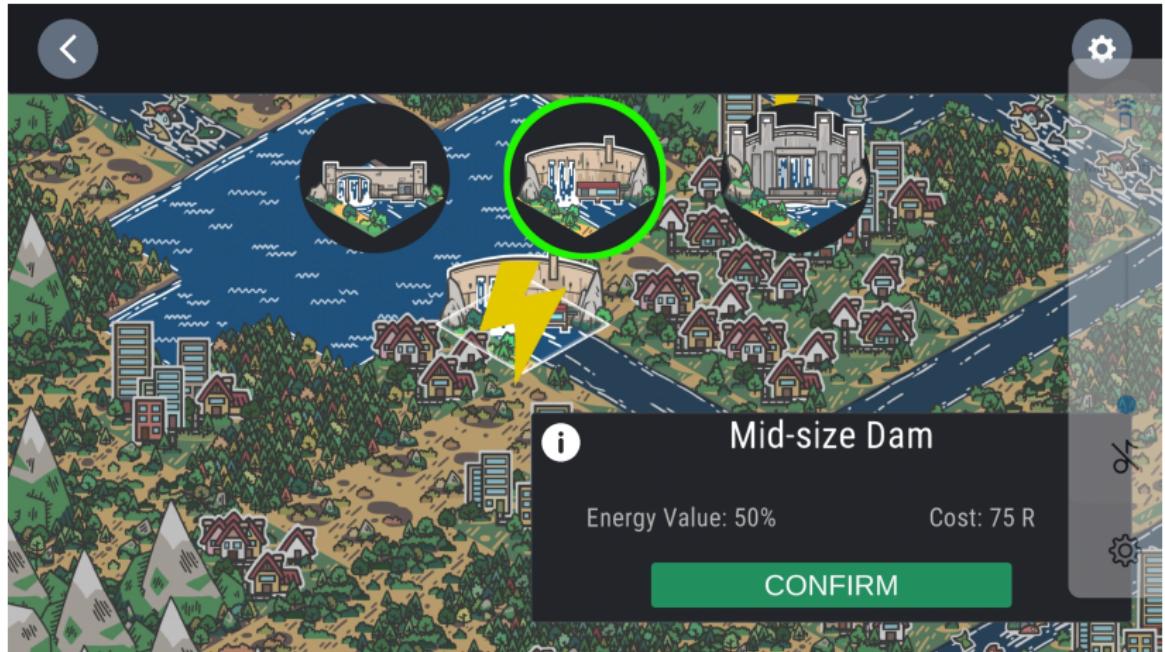
<https://bradduthie.github.io/resevol/>

# BEACON project (mobile app game)



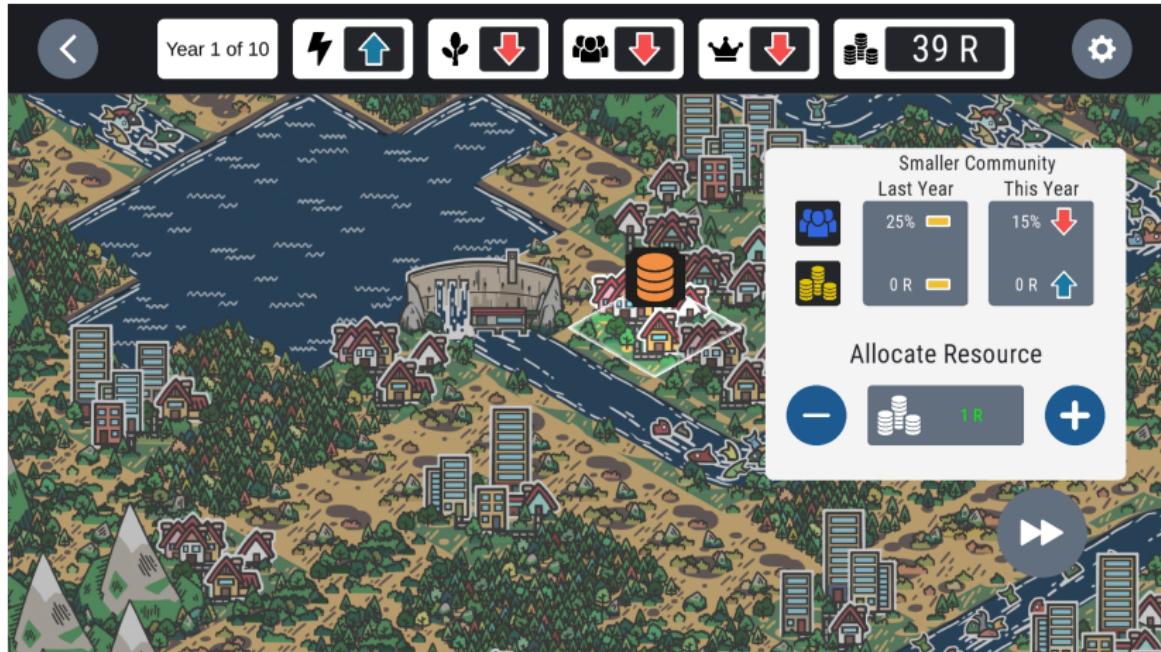
<https://play.google.com/store/apps/details?id=com.hyperluminal.stirlinguniversity.sustainabledevelopmentgame&gl=GB>

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# Power up data collection

## How to best collect game data?

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# Power up data collection

Over 11k rows since January 2023

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59	ResourceChanged	e4e0ce4c-62ec-428b-a4ca-50fe70	1672058051373	0743c3c1	BIOU9CP_GR	16	
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62	ResourceChanged	e4e0ce4c-62ec-428b-a4ca-50fe70	1672058060242	0743c3c1	BIOU9CP_GR	10	
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68	ResourceChanged	e4e0ce4c-62ec-428b-a4ca-50fe70	1672058085870	0743c3c1	BIOU9CP_GR	4	
69	ResourceChanged	e4e0ce4c-62ec-428b-a4ca-50fe70	1672058090036	0743c3c1	BIOU9CP_GR	2	
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71	RandomEvent	e4e0ce4c-62ec-428b-a4ca-50fe70	1672058096452	0743c3c1	BIOU9CP_GR		
72	TurnStart	e4e0ce4c-62ec-428b-a4ca-50fe70	1672058096455	0743c3c1	BIOU9CP_GR	20	
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# Knowledge games for model parameterisation

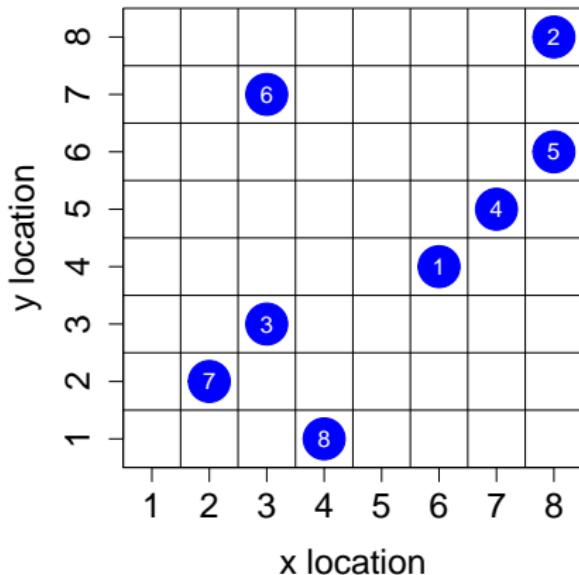
Knowledge games as a free and open tool for data collection<sup>1</sup>.

- ▶ Test hypotheses under simulated conditions
- ▶ Long-term natural experiments *in silico*
- ▶ Big data for agent-based model development



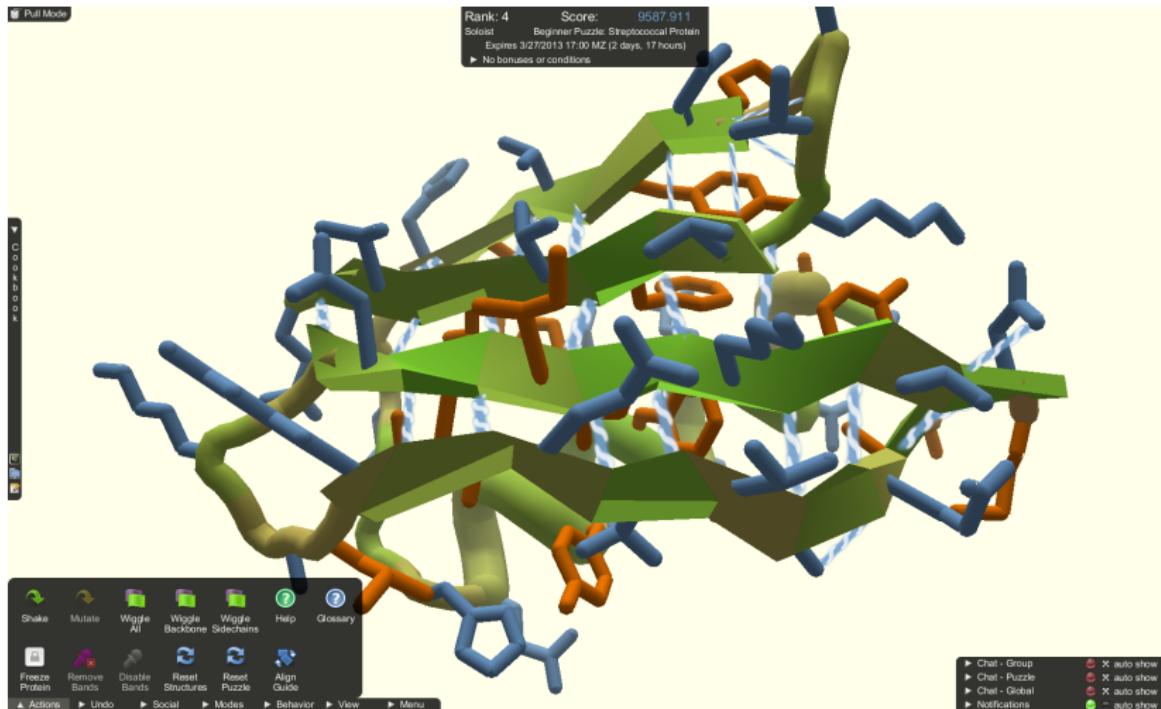
<sup>1</sup>Duthie, AB, et al. 2022. *Conserv. Biol.* 35:1051-1053.

## Agent-based models are often spatially explicit



- ▶ Agent locations can be mapped to a landscape, with rules for movement
- ▶ Landscape can include complex properties and spatial autocorrelation

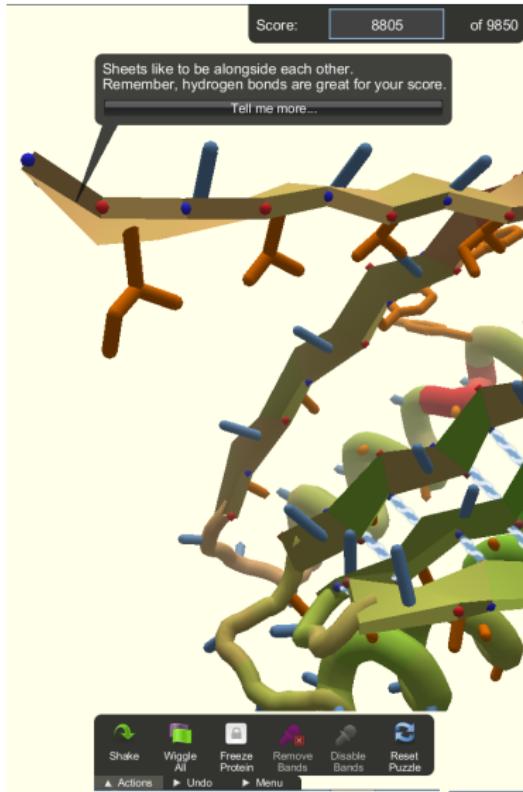
# FoldIt: A game for biochemistry research



<sup>1</sup>Image: <https://fold.it/portal/info/science>

# FoldIt: A game for biochemistry research

- ▶ 50000+ players
- ▶ Support from DARPA, NSF, NIH, HHMI, Microsoft, Adobe, and RosettaCommons
- ▶ 21 papers since 2010



<sup>1</sup>Image: <https://fold.it/portal/info/science>

# LETTER

<https://doi.org/10.1038/v41586-019-1274-4>

nature  
structural &  
molecular biology

## De novo protein design by citizen scientists

Brian Koepnick<sup>1,2</sup>, Jeff Flatten<sup>3</sup>, Tamir Husain<sup>3</sup>, Alex Ford<sup>1,2</sup>, Daniel Adriano Silva<sup>1,2</sup>, Matthew J. Blick<sup>1,2</sup>, Aaron Bauer<sup>1</sup>, Gaohua Liu<sup>1,2</sup>, Yojoji Ishida<sup>4</sup>, Alexander Boykov<sup>1,1</sup>, Roger D. Estep<sup>1</sup>, Susan Kleinfein<sup>1,1</sup>, Toke Nørgråd-Sølano<sup>5</sup>, Linda Weil<sup>1</sup>, Foldit Players<sup>1,2</sup>, Francisco T. Montalvao<sup>1,2</sup>, Frank DiMaio<sup>1,3</sup>, Zoran Popović<sup>1</sup>, Eliezer Khatib<sup>1</sup>, Seth Cooper<sup>1</sup> & David Baker<sup>1,2,5,6</sup>

Online citizen science and protein recognition game Foldit presents Watson-C, however, it represents three-dimensional design in presented as a folded protein.



## Algorithm discovery by protein folding game players

Firas Khatib<sup>1</sup>, Seth Cooper<sup>1</sup>, Michael D. Tyka<sup>1</sup>, Kefan Xu<sup>1</sup>, Ilya Makedon<sup>6</sup>, Zoran Popović<sup>1</sup>, David Baker<sup>1,2,5</sup>, and Foldit Players

<sup>1</sup>Department of Biochemistry, <sup>2</sup>Department of Computer Science and Engineering, and <sup>3</sup>Howard Hughes Medical Institute, University of Washington, Box 357370, Seattle, WA 98195

Contributed by David Baker, October 5, 2011 (sent for review June 29, 2011)

Foldit is a multiplayer online game in which players collaborate and compete to create accurate protein structure models. For specific hard problems, Foldit player solutions can in some cases outperform state-of-the-art computational methods. However, very little is known about how collaborative gameplay produces these results and whether Foldit player strategies can be formalized and

As the players themselves understand their strategies better than anyone, we decided to allow them to codify their algorithms directly, rather than attempting to automatically learn approximations. We augmented standard Foldit play with the ability to create, edit, share, and rate gameplay macros, referred to as "recipes" within the Foldit game (10). In the game each player



nature

Vol 466 | 5 August 2010 doi:10.1038/natur

DOI: 10.1038/nature

## LETTERS

### Predicting protein structures with a multiplayer online game

Seth Cooper<sup>1</sup>, Firas Khatib<sup>1</sup>, Adrien Treuille<sup>1,3</sup>, Janos Barbero<sup>1</sup>, Jeehyung Lee<sup>1</sup>, Michael Beenen<sup>1</sup>, Andrew Leaver-Fay<sup>2,4</sup>, David Baker<sup>2,4</sup>, Zoran Popović<sup>1</sup> & Foldit players

People exert large amounts of problem-solving effort playing computer games. Simple image- and text-recognition tasks have been successfully "crowd-sourced" through games<sup>1–3</sup>, but it is not clear if more complex scientific problems can be solved with human-directed computing. Protein structure prediction is one such

retaining the deterministic Rosetta algorithms as user tool developed a multiplayer online game, Foldit, with the goal of producing accurate protein structure models through gameplay. Improperly folded protein conformations are posted online sites for a fixed amount of time, during which players inter-

## ARTICLE

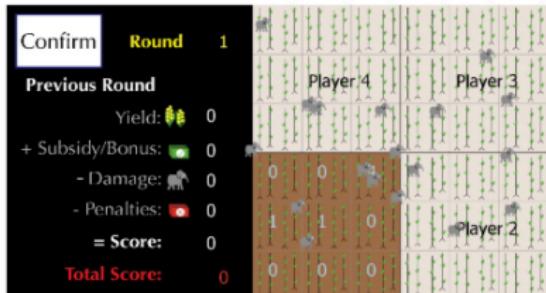
Received 18 Apr 2016 | Accepted 12 Jul 2016 | Published 16 Sep 2016 | Updated 25 Oct 2016

### Determining crystal structures through crowdsourcing and coursework

Scott Horowitz<sup>1,2,\*</sup>, Brian Koepnick<sup>3,\*</sup>, Raoul Martin<sup>1,4,\*</sup>, Agnes Tyminiecki<sup>1,2</sup>, Amandi Seth Cooper<sup>7</sup>, Jeff Flatten<sup>8</sup>, David S. Rogawski<sup>9</sup>, Nicole M. Koropatkin<sup>10</sup>, Tsinatkeab T Philipp Koldewey<sup>1,2</sup>, Logan S. Ahlstrom<sup>1,2</sup>, Matthew R. Chapman<sup>1</sup>, Andrew P. Sikkelma<sup>1</sup>, Finn P. Maloney<sup>13</sup>, Felix R.M. Beinlich<sup>11,14</sup>, Foldit Players<sup>1</sup>, University of Michigan study David Baker<sup>1,3,15,16</sup>, Firas Khatib<sup>17</sup> & James C.A. Bardwell<sup>1,2</sup>

# ConFooBio games (tablet-based and face-to-face)

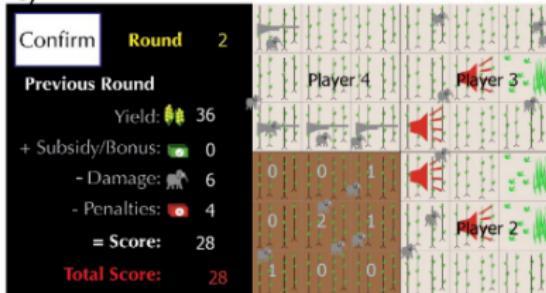
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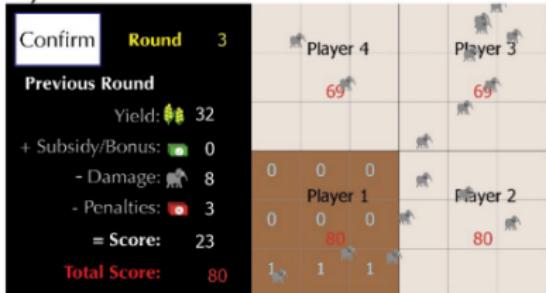
b)



c)



d)

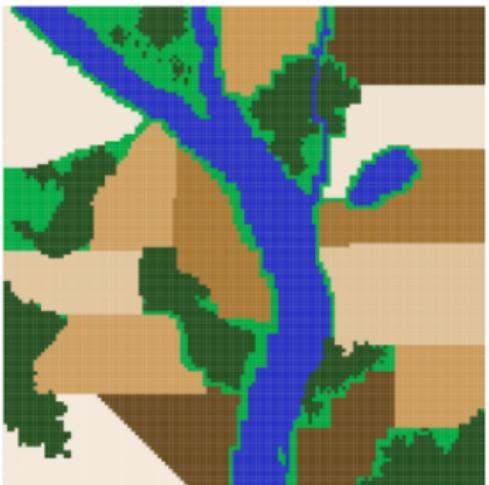
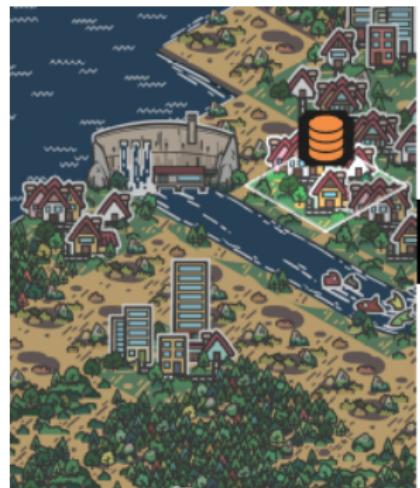


<sup>1</sup>Rakotonarivo, OS, et al. 2021. *Ecol. Soc.* 26:8.

<sup>2</sup>Rakotonarivo, OS, et al. 2021. *People & Nature* 3:162-175.

<sup>3</sup>Rakotonarivo, OS, et al. 2021. *Front. Environ. Sci.* 2:661987.

## Game data to agent-based models



# Game data to agent-based models

