

DENIS PATTERSON

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Research Interests

Applied Analysis Dynamical systems, stochastic processes & functional differential equations
Applications Mathematical Biology: Ecology, biological development & epidemiology

Academic Career

Aug. 2023– **Assistant Professor**, Durham University
Department of Mathematical Sciences

Nov. 2020–Jun. 2023 **Postdoctoral Research Associate**, Princeton University
High Meadows Environmental Institute
Mentor: Prof. Simon A. Levin

July 2018–Oct. 2020 **Postdoctoral Research Associate**, Brandeis University
Department of Mathematics
Mentor: Prof. Jonathan D. Touboul

May 2017–May 2018 **Assistant Professor**, Dublin City University
School of Mathematical Sciences

Oct. 2013–Apr. 2018 **PhD in Applied Mathematics**, Dublin City University
Thesis: *Asymptotic Growth in Nonlinear Stochastic and Deterministic
Functional Differential Equations*
Advisor: Prof. John A. D. Appleby

2009–2013 **BSc in Actuarial Mathematics**, Dublin City University
First class honours

Publications

* corresponding author, \diamond equal contribution, \dagger alphabetical authorship.

Journal Articles

- [J24] K. Shen, S. A. Levin, **D. D. Patterson**^{*}, *Spatial modeling of forest-savanna bistability: Impacts of fire dynamics and timescale separation*, Journal of Mathematical Biology, Vol. 92, No. 44 (2026).
[Open Access]
- [J23] **D. D. Patterson**, L. M. Childs, I. J. Stopard, N. Chitnis, S. Serrato-Arroyo and M. A. Greischar
Immunity can impose a reproduction-survival tradeoff on human malaria parasites, Evolution,
qraf238 (2025).
[Open Access]
- [J22] L. Xu, **D. D. Patterson**, S. A. Levin and J. Wang, *Global stability and tipping point prediction of the coral reef ecosystem*, Earth System Dynamics, Vol. 16, No. 5 (2025).
[Open Access]
- [J21] J. D. Touboul, J. Li, **D. D. Patterson**, S. A. Levin, *New challenges in spatial ecology*, Japanese Journal of Industrial and Applied Mathematics, Vol. 79 (2025).
[Open Access]
- [J20] J. Siu, W. Wu, **D. D. Patterson**, S. A. Levin and J. Wang, *Revealing physical mechanisms of pattern formation and switching in ecosystems via landscape and flux*, Advanced Science, 2501776 (2025).
[Open Access]

- [J19] Z. Qu[◇], **D. D. Patterson**[◇], L. Childs, C. Edholm, J. Ponce, O. Prosper and L. Zhao, *Mathematical modeling of malaria vaccination with seasonality and immune feedbacks*, PLoS Computational Biology, 21(5): e1012988 (2025). [Open Access]
- [J18] **D. D. Patterson**^{*}, S. A. Levin, A. C. Staver and J. D. Touboul, *Pattern formation in mesic savannas*, Bulletin of Mathematical Biology, Vol. 86, No. 3 (2024). [Open Access]
- [J17] **D. D. Patterson**^{*}, A. C. Staver, S. A. Levin and J. D. Touboul, *Spatial dynamics with heterogeneity*, SIAM Journal on Applied Mathematics, S225-S248 (2023). [arXiv]
- [J16] Z. Qu[◇], **D. D. Patterson**[◇], L. Childs, C. Edholm, J. Ponce, O. Prosper and L. Zhao, *Modeling immunity to malaria with an age-structured PDE framework*, SIAM Journal on Applied Mathematics, Vol. 83, No. 3 (2023), 1098–1125. [arXiv]
- [J15] L. Xu, **D. D. Patterson**, S. A. Levin and J. Wang, *Non-equilibrium early-warning signals for critical transitions in ecological systems*, Proceedings of the National Academy of Sciences, Vol. 120, No. 5 (2023), e2218663120.
- [J14] J. Feng[◇], W. H. Hsu[◇], **D. D. Patterson**, C. S. Tseng, Z. H. Zhuang, H. W. Hsin, Y.T. Huang, A. Faedo, J. L. Rubenstein, J. D. Touboul and S.J. Chou, *COUP-TFI specifies the medial entorhinal cortex identity and induces differential cell adhesion to determine the integrity of its boundary with neocortex*, Science Advances, Vol. 7, No. 27 (2021), eabf6808.
- [J13] L. Xu, **D. D. Patterson**, A. C. Staver, S. A. Levin, J. Wang, *Unifying deterministic and stochastic ecological dynamics via a landscape-flux approach*, Proceedings of the National Academy of Sciences, Vol. 118, No. 24 (2021), e2103779118. [arXiv]
- [J12] J. A. D. Appleby and **D. D. Patterson**[†], *Growth and fluctuation in perturbed nonlinear Volterra equations*, Applied Mathematics and Computation, Vol. 396, (2021) 125938. [arXiv]
- [J11] **D. D. Patterson**^{*}, S. A. Levin, A. C. Staver, J. D. Touboul, *Probabilistic foundations of spatial mean-field models in ecology and applications*, SIAM Journal on Applied Dynamical Systems, Vol. 19, No. 4 (2020), 2682–2719. [arXiv]
- [J10] J. A. D. Appleby and **D. D. Patterson**^{*†}, *Blow-up and superexponential growth in superlinear Volterra equations*, Discrete & Continuous Dynamical Systems Series A, Vol. 38, No. 8 (2018), 3993–4017. [arXiv]
- [J9] J. A. D. Appleby and **D. D. Patterson**^{*†}, *Growth rates of sublinear functional and Volterra differential equations*, SIAM Journal on Mathematical Analysis, Vol. 50, No. 2 (2018), 2086–2110. [arXiv]
- [J8] J. A. D. Appleby and **D. D. Patterson**^{*†}, *Memory dependent growth in sublinear Volterra differential equations*, Journal of Integral Equations and Applications, Vol. 29, No. 4 (2017), 531–584. [arXiv]
- [J7] J. A. D. Appleby and **D. D. Patterson**^{*†}, *Large fluctuations and growth rates of linear Volterra summation equations*, Journal of Difference Equations and Applications, Vol. 23, No. 6 (2017), 1047–1080. [arXiv]
- [J6] J. A. D. Appleby and **D. D. Patterson**^{*†}, *Growth rates of solutions of superlinear ordinary differential equations*, Applied Mathematics Letters, Vol. 71 (2017), 30–37. [arXiv]
- [J5] J. A. D. Appleby and **D. D. Patterson**[†], *Hartman–Wintner growth results for sublinear functional differential equations*, Electronic Journal of Differential Equations, Vol. 2017, No. 21 (2017), 1–45. [arXiv]
- [J4] J. A. D. Appleby and **D. D. Patterson**[†], *On the admissibility of unboundedness properties of forced deterministic and stochastic sublinear Volterra summation equations*, Electronic Journal of Qualitative Theory of Differential Equations, No. 63 (2016), 1–44. [arXiv]

- [J3] J. A. D. Appleby and **D. D. Patterson**[†], *Classification of convergence rates of solutions of perturbed ordinary differential equations with regularly varying nonlinearity*, *Electronic Journal of Qualitative Theory of Differential Equations*, Proceedings of the 10th Colloquium on the Qualitative Theory of Differential Equations, No. 3 (2016), 1–38. [arXiv]
- [J2] J. A. D. Appleby and **D. D. Patterson**^{*†}, *Subexponential growth rates in functional differential equations*, *Discrete and Continuous Dynamical Systems Supplement* (2015), 56–65. [arXiv]
- [J1] J. A. D. Appleby and **D. D. Patterson**[†], *On necessary and sufficient conditions for preserving convergence rates to equilibrium in deterministically and stochastically perturbed differential equations with regularly varying nonlinearity*, *Recent Advances in Delay Differential and Difference Equations*, Springer Proceedings in Mathematics & Statistics 94 (2014), 1–85. [arXiv]

Academic Honours & Awards

- 2017 **Outstanding Graduate Researcher Award**, Dublin City University
- 2013–2017 **Government of Ireland Postgraduate Scholarship**, Irish Research Council
- 2013 **Student Actuary Prize**, Society of Actuaries in Ireland
- 2012 **Hamilton Award for Mathematics**, Royal Irish Academy

Selected Academic Talks

- Mar. 2026 **Mathematical Biology Seminar**, University of Edinburgh, UK (invited)
- Oct. 2025 **BioMath Seminar**, University of Florida, USA (invited)
- Oct. 2025 **Mathematical Biology Seminar**, University of Leeds, UK (invited)
- June 2025 **Mathematical Ecology Workshop**, Newcastle University, UK (invited)
- Mar. 2025 **Math Bio Seminar**, New Jersey Institute of Technology, USA (invited)
- Jan. 2025 **Joint Mathematics Meeting**, Seattle, USA (invited)
- Oct. 2024 **SBIDER Seminar**, Zeeman Institute, University of Warwick, UK (invited)
- Apr. 2024 **Models in Population Dynamics, Ecology, and Evolution (MPDEE) '24**,
University of Leicester, UK
- Apr. 2024 **British Applied Mathematics Colloquium**, Newcastle University, UK (invited)
- Apr. 2024 **AMS Spring Sectional Meeting**, Howard University, USA (invited)
- Nov. 2023 **Mathematical Biology Seminar**, University of Illinois, USA (invited)
- Mar. 2023 **AMS Spring Southeastern Sectional Meeting**, Georgia Tech, USA
- Oct. 2022 **International Conference on Mathematical Modeling & Analysis of
Populations in Biological Systems VIII**, Univ. of Louisiana Lafayette, USA
- Oct. 2022 **AMS Fall Eastern Sectional Meeting**, UMass Amherst, USA (invited)
- July 2022 **SIAM Conference on the Life Sciences**, Philadelphia, USA (invited)
- July 2022 **Mathematical Models in Ecology & Evolution (MMEE)**,
University of Reading, UK
- Apr. 2022 **Joint Mathematics Meeting**, online (invited)
- Apr. 2022 **MathBio Seminar**, Arizona State University, USA (invited)
- Mar. 2022 **MathBio Seminar**, Virginia Tech, USA (invited)
- Mar. 2022 **AMS Spring Eastern Sectional Meeting**, online (invited)
- June 2021 **Society for Mathematical Biology Annual Meeting**, online
(*Cell & Developmental Biology Contributed Talk Prize winner*)
- May 2021 **SIAM Conference on Applications of Dynamical Systems**, online

Teaching Experience

Fellow, Higher Education Academy, UK (FHEA)

Professional award from Advance HE for experienced educators with substantive teaching responsibilities.

Courses Lectured

Winter 2025	Computational Mathematics (year 2), Durham University	[webpage]
Winter '23/24/25	Advanced Mathematical Biology (year 4/masters), Durham University	[webpage]
Summer 2020	Differential Equations (fully online), Brandeis University	
Fall 2019	Probability, Brandeis University	
Spring 2019	Multivariate Calculus, Brandeis University	
Winter 2017	Simulation for Finance (year 4/masters), Dublin City University	

Programming & Software

General	C++, Python, R, Julia, Hive, SQL, VBA, Git/Github
Math specific	MATLAB, Mathematica, FreeFEM++, GeoGebra, \LaTeX , XPP/Auto, Matcont, BifurcationKit

Professional Activities & Affiliations

Recent Grants & Research Funding

- 2025 ICMS Research Workshop grant (PI, £21,000)
- 2025 Society for Mathematical Biology Travel Award (PI, \$650)
- 2025 LMS Undergrad Research Bursary – Matthew Black (PI, £2,400)
- 2025 Pascal Fund Award to host a Durham Symposium on Mathematical Biology (co-PI, £5,000)
- 2025 Collaborate@ICERM, “Modeling the Impact of Human Movement on Malaria Immune Dynamics” (co-PI, \$12,000)
- 2024 Biophysical Sciences Institute Flexible Grant – research visit to Cornell University (PI, £1,520)
- 2024 LMS Undergrad Research Bursary – Ewan Green (PI, £2,000)
- 2024 Biophysical Sciences Institute Undergrad Research Bursary – Thomas Shaw (PI, £3,400)
- 2024 Seedcorn Grant from Durham University, “Microbial multiculture coexistence: Metals as resources and toxins” (PI, £10,000)
- 2023 Durham University Research Staff Association Travel Grant (PI, £700)
- 2022 Convergence Accelerator Team Award from the NSF-Simon’s Center for Multiscale Cell Fate Research (UC Irvine) for the project “Developing methodologies for spatial and demographic heterogeneity in malaria immune dynamics” (\$10,500)
- Selected participant in the AMS Mathematical Research Community “Dynamics of Infectious Diseases”, 2020-2022 (\$3,125)

Workshops & Organizational Activities

- Conference & workshops organized:
 - “Infectious Disease Modeling across scales” funded and hosted by the American Institute of Mathematics, April 2023
 - “Critical Transition Workshop Series”: Part I, Part II, 2022 (virtual), and Part III, 2023 (hosted by Princeton University)

- “Climate & Math Conference”, Brandeis University, May 26th, 2022 (virtual)
- Minisymposia/special sessions organized:
 - “Dynamics and asymptotics in biological media” at the British Applied Mathematics Colloquium (2025), University of Exeter, UK
 - “Nonlinear Systems in Mathematical Biology” at the British Applied Mathematics Colloquium (2024), Newcastle University, UK
 - “Multiscale Approaches to Modeling Ecological and Evolutionary Dynamics” at the AMS Southeastern Spring Sectional Meeting (2023), Georgia Tech, USA
 - “Dynamics of PDEs on heterogeneous domains: Theory & applications” at the Joint Mathematics Meeting (JMM 2023), Boston MA, USA
 - “Vegetation Modeling: Nonlinear PDE approach” at Mathematical Models in Ecology & Evolution Conference (MMEE 2022), University of Reading, UK
 - “Stochastic Networks in Neuroscience and Ecology” at the SIAM Conference on Applications of Dynamical Systems (DS21), Virtual

Reviewing

EPSRC Peer Review College member and reviewer for the following academic journals:

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|--------------------------------------------------------------------------|---------------------------------------------------|
| • Applied Mathematics and Computation | • Mathematical Biosciences |
| • Applied Mathematical Modelling | • Mathematical Biosciences and Engineering |
| • Bulletin of Mathematical Biology | • Nature Communications |
| • Chaos: An Interdisciplinary Journal of Nonlinear Science | • Nonlinear Dynamics |
| • Ecological Modelling | • Nonlinearity |
| • Electronic Journal of the Qualitative Theory of Differential Equations | • Physica D |
| • European Journal of Applied Mathematics | • Proceedings of the National Academy of Sciences |
| • Journal of Difference Equations and Applications | • PLoS Computational Biology |
| • Journal of Nonlinear Science | • SIAM Journal on Applied Mathematics |
| • Journal of the Royal Society Interface | • Theoretical Population Biology |
| | • Theoretical Ecology |

Outreach and Diversity, Equity & Inclusion Activities

- Deputy Early Career Representative, Mathematical Sciences Departmental Leadership Team (2025-)
- First Generation Scholars Lead, Mathematical Sciences, Durham University (2024-)
- EDI Committee Member & Webmaster, Mathematical Sciences, Durham University (2023-)
- EEB Scholars Program invited panellist, Fall 2022, Princeton University
- Postdoctoral representative on the *Diversity & Inclusion Climate Committee* and *Outreach Subcommittee* member, Princeton University (2021-2022)
- Speaker for the “MRSEC Pizza Talks” science outreach program at Waltham High School, Fall 2020
- Judge for SCUDEM 2020, 2021 and 2024 (high school/undergraduate mathematical modeling competition)
- University coordinator for the BITE/DCU Voluntary Math Tuition programme 2017/2018 (math outreach to disadvantaged schools to promote university access through tutoring and mentorship)
- DCU Access Service tutor 2015/2016 (academic support for disadvantaged university students)

Professional Memberships

- Institute of Mathematics and its Applications (IMA)
- Society for Mathematical Biology (SMB)