Dr. James R. Beattie

updated: 18-Jan-2024

Personal Information

NATIONALITY:	· Australia · New Zealand
POSITIONS:	· Joint Princeton & CITA Postdoctoral Fellow in astrophysical plasmas
EMAIL:	· james.beattie@princeton.edu · jbeattie@cita.utoronto.edu
Online Profiles	· Google Scholar · ResearchGate · OrcID · Twitter
INTERESTS:	· MHD / HD turbulence · structure of the interstellar medium · star-formation
	· high-performance computing · theoretical astrophysics · magnetic fields
	· cosmic ray propagation · plasma/fluid dynamics · shocks · turbulent dynamo
	· computer vision techniques · statistical modelling · interdisciplinary research

Education

2024   **Doctor of Philosophy**, Australian National University, Australia
Specialisation: Computational / theoretical astrophysics, magnetohydrodynamics.
Thesis: The statistics of magnetised interstellar turbulence
Advisor: Christoph Federrath

2019   **Honours (First Class)**, Australian National University, Australia
Major: Astrophysics
Thesis: Supersonic Turbulent Molecular Clouds: Filaments and Anisotropies
(with University Medal, Chancellor's Commendations, Bok Prize)

2018   **Bachelor of Mathematics**, Queensland University of Technology, Australia
Major: Applied and Computational Mathematics

2018   **Bachelor of Science**, Queensland University of Technology, Australia
Major: Physics

2013   **Bachelor of Education**, Queensland University of Technology, Australia
Major: Biology & Computing

Exchange and Summer Programmes

2022-23	Fulbright Exchange at the University of California, Santa Cruz, United States
2017-18	Cross Institutional Exchange at the University of Queensland, Australia
WINTER 2017	Summer Science Programme at The University of Cambridge, United Kingdom
FALL 2015	Exchange Semester at Simon Fraser University, Canada

Scholarships, Awards & Grants

Selected Scholarships & Fellowships

2023	CITA Fellow, CITA
2023	Research Associate, Princeton University
2023	Stanford Science Fellow, Stanford (declined)
2022	Fulbright PhD Fellowship
2020	Joan Duffield Research Supplementary Scholarship
2020	Deakin PhD Scholarship
2020	Dean's Merit (theoretical physics) HDR Supplementary Scholarship
2019	Bok Honours Astrophysics Scholarship

Selected Significant Awards

2020	Chancellor's Letter of Commendation: 7.0/7.0 Honours GPA
2020	ASA Bok Prize: Best Astronomy Honours Thesis in Australia
2020	Best Student Talk at ANITA, 2020
2019	University Medal (top in graduating science cohort)
2018	Admission to the Dean's List of Students with Excellent Academic Performance
2018	Vice Chancellor's Performance Award
2018	Nominated for 2018 Vice-Chancellor's Awards for Excellence
2016	Vice Chancellor's Performance Award: Best Sessional Teaching in Science & Engineering Faculty

2016	Admission to the Dean's List of Students with Excellent Academic Performance
2015	Admission to the Dean's List of Students with Excellent Academic Performance
2014	Admission to the Dean's List of Students with Excellent Academic Performance

Computing grants awarded (1 core hour $\approx \$0.13$)

2022	(PI) LRZ large scale call extension	1.5e7 core hours
2021	(PI) LRZ large scale call: The world's largest compressible MHD simulation	7e7 core hours

Competitive Grants Awarded (PI / CO-PI)

2021	(CO-PI) Australian Capital Territory Summer Holiday Grant, Inspire ACT
2020	(CO-PI) Australian Capital Territory National Science Week Grant
2020	(PI) SSAP Grant for Mt Stromlo Student Seminars, 2020

Selected Minor Awards

2018	Joint funding from the ANU and QUT to present at the Australian Institute of Physics (AIP) Congress, 2018
2017	GHD Groundwater Modelling Award for Best Overall Group Submission
2017	Financial Sponsorship from the CPME and Mathematical Science School for the Cambridge Summer Science Programme
2017	Recipient of QUT's International short-term mobility bursary
2015	Recipient of QUT's International Bursary
2014	Best Paper Finalist | Australasian Conference on Robotics and Automation

Selected non-professional awards

2023	Astro. Plot of the Week (Figure 3)
2022	Astro. Plot of the Week (Figure 1)

PROFESSIONAL ACTIVITIES & ORGANISATION AFFILIATIONS

Professional Activities

Referee for the · Astrophysical Journal (2 articles) · Monthly Notices of the Astronomical Society (3 articles), · Publications of the Astronomical Society of the Pacific (1 article).

2023	Coordinator for the Canadian Institute of Astrophysics Astro-Plasma Group
2022	MSATT program – connecting scientists with high school students
2022	Sustainability Committee, Member, RSAA
2021	Higher Degree Research Education Representative, RSAA
2021	Giving Committee, Member, RSAA
2020	President of the RSAA Student Seminar Committee
2019	ASTR4004, ANU Course Student Representative
2019	ASTR6007, ANU Course Student Representative
2014-16	QUT's STIMULATE Learning Support, Peer Learning Facilitator

Organisation Affiliations

2020 - PRES.	Astronomical Society of Australia, student member
2014-18	QUT Physics Society, founding president
2016	QUT's Science Student as Partners, physics representative.
2016	UQ's Student as Partners, Fellow
2015	Australian Institute of Physics, QLD Branch, QUT representative

SUPERVISIONS & MENTORING

Supervisions

2023 **Student**: Shashvat Varma, Undergrad. Student, University of Toronto.
Project: The fast-in-time dynamics of the small-scale dynamo

2023 **Student**: Sam Lakerdas-Gayle, Undergrad. Student, University of Toronto.
Project: The secret-life of over-dense regions in magnetised, turbulent clouds

2021 **Student**: Neco Kriel (co-supervised w. Mark Krumholz), Honours Student, ANU.
Project: Fundamental scaling relations in the turbulent dynamo.

Student: Matthew Sampson (co-supervised w. Christoph Federrath), Honours Student, ANU.
2021 **Project:** Cosmic ray transport in compressible ionised MHD turbulence.

Mentorships

2022 **Student**: Adrian Lehane, Telopea Park School / Narrabundah College (high school).
Project: Automated phase detection of Venus.

TALKS

Invited (16 total)

APR. 2024	Invited to CITA Blackboard Theory Seminar
MAR. 2024	Invited to University Maryland Comp. Seminar and Theory
FEB. 2024	Invited to CITA Theory Seminar
NOV. 2023	The most fascinating part of interstellar turbulence: the energy cascade Presented at: TASTY Seminar Series, University of Toronto.
MAY 2023	The World's Largest Compressible MHD Turbulence Simulation on SuperMUC-NG Presented at: SuperMUC-NG Status and Results Workshop.
SEP. 2022	KIPAC Tea talk: Peta-scale magnetised interstellar medium turbulence simulations. Presented at: SLAC / Stanford University.
SEP. 2022	Magnetised interstellar medium turbulence: dynamics & energetics. Presented at: Susan Clark's research group, Stanford.
SEP. 2022	Astro-coffee: Streaming cosmic rays ion Alfvén velocity statistics. Presented at: Institute for Advanced Study.
SEP. 2022	Bachall lunch discussion: peta-scale simulations & turbulent dynamics. Presented at: Institute for Advanced Study.
APR. 2022	Streaming cosmic rays ion Alfvén velocity statistics. Presented at: Siang Peng Oh's research group, UC Santa Barbara.
NOV. 2021	Ubiquitous magnetic field fluctuations driven by large-scale supersonic turbulence. Presented at: Star formation and ISM Physics Seminar, Princeton.
JAN. 2021	Ubiquitous magnetic field fluctuations driven by large-scale supersonic turbulence. Presented at: Research School of Astronomy and Astrophysics seminar, ANU.
JUL. 2020	The Anisotropic Density Variance for Highly-Magnetised Molecular Clouds. Presented at: Astronomical Society of Australia Bok Prize talk.
JUN. 2020	Turbulence at the parsec scale of the Universe. Presented at: Research highlight talk at RSAA full school meeting.
AUG. 2018	The Fractal Geometry of the Supersonic Turbulence in the Interstellar Medium. Presented at: QUT research highlights.
MAY 2018	The Fractal Geometry of Turbulence. Presented at: QUT Physics Society Meeting.

Colloquium (3 total)

AUG. 2020	The Anisotropic Density Variance for Highly-Magnetised Molecular Clouds. Presented at: University of Macquarie Colloquium.
NOV. 2017	The University of Cambridge and Quantum Mechanics. Presented at: School of Chemistry, Physics and Engineering Colloquium, QUT.
NOV. 2017	Mathematical Aspects of Mechanics. Presented at: School of Mathematical Sciences Colloquium, QUT.

Contributed (14 total)

FEB. 2022	Petascale magnetised interstellar medium turbulence simulations Presented at: ANITA 2022 Workshop.
DEC. 2021	Understanding the nature of magnetic field fluctuations driven by large-scale supersonic turbulence. Presented at: Australian Institute of Physics Congress, QUT.
OCT. 2021	Understanding the nature of magnetic field fluctuations driven by large-scale supersonic turbulence. Presented at: Royal Astronomical Society: Galactic magnetic fields meeting.
FEB. 2021	Steps towards anisotropic star formation theory: A multi-shock model for the density variance of anisotropic MHD turbulence. Presented at: ANITA 2021 Workshop.
DEC. 2020	Multi-shock model for the density variance of anisotropic, highly-magnetised ISM turbulence. Presented at: The Magnetic Field Awakens: A new era of star formation.
NOV. 2020	Recent progress on anisotropic, magnetised, supersonic turbulence. Presented at: Mount Stromlo Student Seminars, 2020.
SEP. 2020	Is the Starry Night Turbulent? Presented at: RSAA Feast of Facts.
FEB. 2020	Density, velocity and magnetic structures and correlations in sub-Alfvénic, supersonic turbulence. Accepted* for contributed talk: Magnetic Fields in the Universe 7, Vietnam.
FEB. 2020	Anisotropy in the column density of highly-magnetised supersonic turbulence. Presented at: ANITA 2020 Workshop, UNSW, Canberra.

Dec. 2019	Anisotropic structures in highly-magnetised, observed turbulent clouds. Presented at: Universality: Turbulence across vast scales, Flatiron Inst., New York
Nov. 2019	Reconstructing the 3D Density PDF from the 2D Column Density. Presented at: Cosmic turbulence and magnetic fields : physics of baryonic matter across time and scales in Cargese, France, 2019.
Dec. 2018	Mach number - fractal dimension relation for turbulent, molecular clouds. Poster presented at: AIP Congress 2018, Perth, Australia.
Jan. 2018	The Fractal Geometry of the World's Largest Turbulence Simulation. Presented at: Research School of Astronomy and Astrophysics, ANU.
Jan. 2017	The Analysis of Novel Magnetic Field Configurations in the H-1 NF Stellarator. Presented at: Research School of Physics and Engineering, ANU.

* did not attend due to COVID19

Public Outreach Talks (10 total)

Aug. 2021	Building the Universe, Brick-by-brick. Presented at: Young Stars, ANU, Canberra.
May. 2021	Understanding The Big Bang. Presented at: Young Stars, ANU, Canberra.
Mar. 2021	The Secret Life of Cells. Presented at: Young Stars, ANU, Canberra.
Jan. 2021	Mission to Mars. Presented at: Young Stars, ANU, Canberra.
Jan. 2021	The Jiggling Universe. Presented at: SciScouts Space Squad, Canberra.
Nov. 2020	The Jiggling Universe. Presented at: Campbell Primary School STEM day, Canberra.
Oct. 2020	Thinking Like An Atom. Presented at: Young Stars, Canberra.
Sep. 2020	Simulating the Universe. Presented at: SciScouts Space Squad, Canberra.
Mar. 2020	Modelling Pandemics. Presented at: Young Stars, Canberra.
Feb. 2020	How do scientists test their ideas? Presented at: Young Stars, Canberra.

Teaching (23 total contributions)

Guest Lectures

Oct. 2022	ASTR8002 (ANU): Guest lecture on MHD turbulence theory for a graduate level gas dynamics class.
Oct. 2020	ASTR8002 (ANU): Guest lecture on linear MHD waves for a graduate level gas dynamics class.

TA experience (Click on the "Semester" to see teacher evaluation reports)

2021	**Australian National University**, Canberra, Australia	
	ASTR2013: Foundations of Astrophysics	Semester Two

2018	**Queensland University of Technology**, Brisbane, Australia	
	PVB101: Physics of the Large	Semester Two
	MXB105: Calculus of One and Two Variables (wrote all assessment)	Semester Two
	MXB161: Computational Explorations	Semester One
	SEB113: Quantitative Methods in Science	Semester One & Two
	SEB104: Grand Challenges in Science	Semester One
	SEB115: Experimental Science	Semester One

2017	**Queensland University of Technology**, Brisbane, Australia	
	MXB105: Calculus of One and Two Variables	Semester Two
	PVB101: Physics of the Large (Lab Demonstrator)	Semester Two
	BVB204: Ecology	Semester Two
	SEB113: Quantitative Methods in Science	Semester One & Two
	SEB104: Grand Challenges in Science	Semester One
	SEB115: Experimental Science (Lab Demonstrator)	Semester One
	MXB161: Computational Explorations	Semester One

2016	**Queensland University of Technology**, Brisbane, Australia	
	PVB101: Physics of the Large (Lab Demonstrator)	Semester Two
	BVB202: Plant Biology (Lab Demonstrator)	Semester Two
	BVB224: Plant Diversity (Lab Demonstrator)	Semester Two
	SEB113: Quantitative Methods in Science	Semester One & Two
	SEB104: Grand Challenges in Science	Semester One
	SEB115: Experimental Science (Lab Demonstrator)	Semester One

2015	**Queensland University of Technology**, Brisbane, Australia	
	SEB113: Quantitative Methods in Science	Semester One

Publications

· **First author:** 12 publications (10 refereed)   · **Total:** 25 publications
· **Citations:** 483 (18-Jan-2024)   · **h index:** 13 (18-Jan-2024)

First Author (and joint first) Refereed (10 total)

<u>Beattie</u>, **J. R.**, & Federrath, C. (2020). Filaments and striations: anisotropies in observed, supersonic, highly magnetized turbulent clouds. *MNRAS, 492*(1), 668–685. https://doi.org/10.1093/mnras/stz3377

<u>Beattie</u>, **J. R.**, Federrath, C., & Klessen, R. S. (2019). The relation between the true and observed fractal dimensions of turbulent clouds. *MNRAS, 487*(2), 2070–2081. https://doi.org/10.1093/mnras/stz1416

<u>Beattie</u>, **J. R.**, Federrath, C., Klessen, R. S., & Schneider, N. (2019). The relation between the turbulent Mach number and observed fractal dimensions of turbulent clouds. *MNRAS, 488*(2), 2493–2502. https://doi.org/10.1093/mnras/stz1853

<u>Beattie</u>, **J. R.**, Federrath, C., Kriel, N., Mocz, P., & Seta, A. (2023). Growth or decay – I: universality of the turbulent dynamo saturation. *arXiv e-prints*, arXiv:2209.10749.

<u>Beattie</u>, **J. R.**, Federrath, C., & Seta, A. (2020). Magnetic field fluctuations in anisotropic, supersonic turbulence. *MNRAS, 498*(2), 1593–1608. https://doi.org/10.1093/mnras/staa2257

<u>Beattie</u>, **J. R.**, Krumholz, M. R., Federrath, C., Sampson, M. L., & Crocker, R. M. (2022). Ion alfvén velocity fluctuations and implications for the diffusion of streaming cosmic rays. *Frontiers in Astronomy and Space Sciences, 9*. https://doi.org/10.3389/fspas.2022.900900

<u>Beattie</u>, **J. R.**, Krumholz, M. R., Skalidis, R., Federrath, C., Seta, A., Crocker, R. M., Mocz, P., & Kriel, N. (2022). Energy balance and Alfvén Mach numbers in compressible magnetohydrodynamic turbulence with a large-scale magnetic field. *MNRAS*. https://doi.org/10.1093/mnras/stac2099

<u>Beattie</u>, **J. R.**, Mocz, P., Federrath, C., & Klessen, R. S. (2021). A multishock model for the density variance of anisotropic, highly magnetized, supersonic turbulence. *MNRAS, 504*(3), 4354–4368. https://doi.org/10.1093/mnras/stab1037

<u>Beattie</u>, **J. R.**, Mocz, P., Federrath, C., & Klessen, R. S. (2022). The density distribution and physical origins of intermittency in supersonic, highly magnetised turbulence with diverse modes of driving. *MNRAS*. https://doi.org/10.1093/mnras/stac3005

Birch, M., <u>Beattie</u>, **J. R.**, Bennet, F., Rattenbury, N., Copeland, M., Travouillon, T., Ferguson, K., Cater, J., & Sayat, M. (2023). Availability, outage, and capacity of spatially correlated, australasian free-space optical networks. *J. Opt. Commun. Netw., 15*(7), 415–430. https://doi.org/10.1364/JOCN.480805

Second Author or Major Contributions Refereed (8 total)

Federrath, C., Klessen, R. S., Iapichino, L., & <u>Beattie</u>, **J. R.** (2021). The sonic scale of interstellar turbulence. *Nature Astronomy, 5*, 365–371. https://doi.org/10.1038/s41550-020-01282-z.

Measured the sonic scale position from the second order structure functions and contributed to writing the manuscript.

Kriel, N., <u>Beattie</u>, **J. R.**, Seta, A., & Federrath, C. (2022). Fundamental scales in the kinematic phase of the turbulent dynamo. *MNRAS*. https://doi.org/10.1093/mnras/stac969.

Developed the spectral fitting methodology, spectral models, taught Kriel how to use the FLASH code throughout the project and contributed to writing the manuscript.

McCool, C., <u>Beattie</u>, **J. R.**, Firn, J., Lehnert, C., Kulk, J., Bawden, O., Russell, R., & Perez, T. (2018). Efficacy of mechanical weeding tools: A study into alternative weed management strategies enabled by robotics. *IEEE Robotics and Automation Letters, 3*(2), 1184–1190. https://doi.org/10.1109/LRA.2018.2794619.

Developed and applied the survival analysis models used to compare between the different automated weeding strategies and contributed to writing the manuscript.

McCool, C., <u>Beattie</u>, **J. R.**, Milford, M., Bakker J. D., J. L., Moore, & Firn, J. (2018). Automating analysis of vegetation with computer vision: Cover estimates and classification. *Ecology and Evolution, 8*(12), 6005–6015. https://doi.org/10.1002/ece3.4135.

Developed and applied the statistical model for comparing between the different computer vision techniques and contributed to writing the manuscript.

Risch, A. C., Page-Dumroese, D. S., Schweiger, A. K., <u>Beattie</u>, **J. R.**, Curran, M. P., Finér, L., Liu, Y., Schütz, M., Terry, T. A., Wang, W., & Jurgensen, M. F. (2022). Controls of initial wood decomposition on and in forest soils using standard material. *Frontiers in Forests and Global Change, 5*, 829810. https://doi.org/10.3389/ffgc.2022.829810.

Constructed the principle data set, developed and ran parallelised hierarchical Bayesian

mixed effects models and model selection methods.

Sampson, M. L., **Beattie**, **J. R.**, Krumholz, M. R., Crocker, R. M., Federrath, C., & Seta, A. (2023). Turbulent diffusion of streaming cosmic rays in compressible, partially ionized plasma. *MNRAS*, *519*(1), 1503–1525. https://doi.org/10.1093/mnras/stac3207.

> **Ran all MHD turbulence models, provided analytical Green's function solutions to the diffusion problems, helped develop the theory and fitting for fractional diffusion transport and contributed to writing the manuscript.**

Skalidis, R., Sternberg, J., **Beattie**, **J. R.**, Pavlidou, V., & Tassis, K. (2021). Why take the square root? An assessment of interstellar magnetic field strength estimation methods. *A&A*, *656*, Article A118, A118. https://doi.org/10.1051/0004-6361/202142045.

> **Ran all MHD turbulence simulations and contributed to the theoretical development of the coupling term energy model and drafting the manuscript.**

Thomas, M. L., Baker, L., **Beattie**, **J. R.**, & Baker, A. M. (2020). Determining the efficacy of camera traps, live capture traps, and detection dogs for locating cryptic small mammal species. *Ecology and Evolution*, *10*(2), 1054–1068. https://doi.org/10.1002/ece3.5972.

> **Developed and applied the occupancy analysis models used to compare between the different detection methods and contributed to writing the manuscript.**

Multi-author Refereed (4 total)

Milford, M., Firn, J., **Beattie**, **J.**, Jacobson, A., Pepperell, E., Mason, E., Kimlin, M., & Dunbabin, M. (2014). Automated sensory data alignment for environmental and epidermal change monitoring. *Australasian Conference on Robotics and Automation 2014*, 1–10. https://eprints.qut.edu.au/81684/

Schneider, N., Ossenkopf-Okada, V., Clarke, S., Klessen, R. S., Kabanovic, S., Veltchev, T., Bontemps, S., Dib, S., Csengeri, T., Federrath, C., Di Francesco, J., Motte, F., André, Ph., Arzoumanian, D., Beattie, J. R., Bonne, L., Didelon, P., Elia, D., Könyves, V., ... Ward-Thompson, D. (2022). Understanding star formation in molecular clouds - iv. column density pdfs from quiescent to massive molecular clouds. *A&A*, *666*, A165. https://doi.org/10.1051/0004-6361/202039610

Seligman, D. Z., Rogers, L. A., Feinstein, A. D., Krumholz, M. R., **Beattie**, **J. R.**, Federrath, C., Adams, F. C., Fatuzzo, M., & Günther, M. N. (2022). Theoretical and Observational Evidence for Coriolis Effects in Coronal Magnetic Fields via Direct Current Driven Flaring Events. *ApJ*, *929*(1), Article 54, 54. https://doi.org/10.3847/1538-4357/ac5b69

Sharda, P., Menon, S. H., Federrath, C., Krumholz, M. R., **Beattie**, **J. R.**, Jameson, K. E., Tokuda, K., Burkhart, B., Crocker, R. M., Law, C. J., Seta, A., Gaetz, T. J., Pingel, N. M., Seitenzahl, I. R., Sano, H., & Fukui, Y. (2022). First extragalactic measurement of the turbulence driving parameter: ALMA observations of the star-forming region N159E in the Large Magellanic Cloud. *MNRAS*, *509*(2), 2180–2193. https://doi.org/10.1093/mnras/stab3048

Preprints Undergoing Review or Other (3 total)

Beattie, **J. R.**, Federrath, C., Kriel, N., Hew, J. K. J., & Bhattacharjee, A. (2023). Taking control of compressible modes: bulk viscosity and the turbulent dynamo. *arXiv e-prints*, Article arXiv:2312.03984, arXiv:2312.03984. https://doi.org/10.48550/arXiv.2312.03984

Beattie, **J. R.**, & Kriel, N. (2019). Is The Starry Night Turbulent? *arXiv e-prints*, arXiv:1902.03381.

Kriel, N., **Beattie**, **J. R.**, Federrath, C., Krumholz, M. R., & Hew, J. K. J. (2023). Fundamental MHD scales – II: the kinematic phase of the supersonic small-scale dynamo. *arXiv e-prints*, Article arXiv:2310.17036, arXiv:2310.17036. https://doi.org/10.48550/arXiv.2310.17036

Media (18 total)

2024	The world's largest magnetohydrodynamic turbulence simulation, *Forschung Magazine*
2024	German Research Foundation (DFG) 2024 Calendar (March visualisation)
2022	Unravelling magnetised turbulence in galaxies, *Lunations, Research Bytes*
2022	The Magic And Mystery Of Turbulence, *IFL Science*
2021	Extreme efficiency astrophysical turbulence simulations, *National Computing Infrastructure, Australia*
2021	Coffee, planes and magnetism. *Space Australia, TikTok*
2021	Unravelling the turbulent, magnetised dynamics of the interstellar medium. *Space Australia*
2021	Turbulence in the heavens, *Nature Astronomy, News & Views.*
2021	Researchers Use LRZ HPC Resources to Perform Largest-Ever Supersonic Turbulence Simulation, *Gauss Centre for Supercomputing*

2021	The Role of Turbulence in the Birth of Stars, *University Heidelberg.*
2021	Star-making motion, COSMOS magazine
2021	Study helps unlocks secrets of star formation, *ANU Media*
2021	Stellar Simulation Reveals The Turbulent Nature of Star Birth, Space Australia.
2021	The Need for (Sound) Speed, *Astrobite research highlight*
2019	Modelling Star Formation with a Supercomputer: Computational Astrophysics Research, *National Computing Infrastructure Australia*
2019	Feature article on turbulence depicted in Van Gogh's Starry Night in the Art's and Culture section of the American Physical Societies Magazine.
2018	QUT advertising photoshoot for the BSc and BMath degree on QUT's blackboard website.
2018	QUT media exposure, and photoshoot for our publication, Automating Analysis of Vegetation with Computer Vision: cover estimates.