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Building capacity in Bayesian analysis for practicing ecologists

External Evaluation Report

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Introduction

From 2013 to 2016 this project offered intensive training on hierarchical Bayesian methods to 85 post-doctoral researchers, academic faculty, and scientists at agencies and non-governmental organizations; 35 (41%) were females and 50 (59%) were males. The project trained individuals from nine countries (Australia, Brazil, Canada, Mexico, Nigeria, Panama, Scotland, Spain and United Kingdom), two U.S. territories (Puerto Rico and Virgin Islands), the District of Columbia and 32 U.S. states. (A display of the U.S. states is included in Appendix A.) Seventy-seven percent (77%) of the attendees came from institutions in the United States.

The purpose of this summative external evaluation is to assess the impact of the project's trainings on 71 of the 85 workshop participants who completed a July 2016 online questionnaire that was developed collaboratively with the Principal Investigator. This was a response rate of 84%. Response rates for trainees who participated in the project's training (aka. course) each of the four years are displayed in the following table.

Response Rates for 2013-2016 Trainees

Year	Number of Trainees	Number of Respondents	Response Rate
2013	20	13	65%
2014	22	19	95%
2015	21	17	81%
2016	22	22	100%

Findings

Most (97%) of the respondents were from domestic, territorial and international universities and government agencies. Eleven participants (seven postdoctoral researchers, three scientists and an assistant professor) moved to different positions since participating in the training. One of the postdoctoral researchers acknowledged the training as an important factor in being hired into the new position.

Transportation and lodging costs made the stipend they received essential to 45% of the respondents who would not have been able to attend the training without financial support. Although 30% of the respondents indicated that they might have been able to attend the training at Colorado State University without financial support most of these individuals said that doing so would have been difficult. There was no discernable common characteristic among the 25% of respondents who reported that they would have been able to participate in the training if a stipend had not been provided. The financial support provided by this grant made it possible for a large number of participants to attend the training, and it is likely that rising costs associated with attending the training will require a higher level of financial support in the future.

Respondents said repeatedly in recorded comments that the training was outstanding. An important feature of this well planned and organized training was that the gradational development of topics formed a cohesive, meaningful learning experience that made the material accessible to participants with a variety of statistical backgrounds. Understanding was enhanced because structure and time were provided for hands-on experiences during which participants reflected on concepts, strategies and issues. The background, experience, and expertise of the instructors contributed to the success of the training. As a result participants reported increased skill and knowledge in applying Bayesian methods in their research, teaching, and research decision making. Although several participants left the training feeling less than

confident about their Bayesian modeling skills they felt the training was valuable to them and they have continued to work on understanding the topics better. It appeared that some participants might benefit from a second training where they could get support for increasing the depth of their understanding of the training topics and in developing their own models.

Respondents (retrospectively) rated (1 to 10, 10 high) their pre- and post-training level of expertise for reviewing papers and proposals that use Bayesian analysis as part of their text. The frequency distribution of recorded ratings revealed the large effect the training had on increasing their levels of expertise. The pre- and post-training means were 2.2 and 6.4, respectively. The most important insights participants reported reflected the anticipated learning outcomes of the project which were to 1) explain key principles of Bayesian statistics, 2) use basic statistical distributions in hierarchical Bayesian models, 3) use Markov Chain Monte Carlo methods, 4) understand and use JAGS and R software, 5) develop and implement hierarchical models, and 6) evaluate strength of evidence in alternative models for ecological processes.

The training influenced or shaped new graduate level courses, the modification of existing courses, publications (journal, policy and management technical reports, monographs, books and book chapters), dissertations, theses, workshops, seminars, presentations, grant proposals, and awards (two NSF). Forty individuals responded, "Yes" when asked if their participation in the project influenced or shaped published papers in peer reviewed journals. In addition to realized publications, respondents reported twelve papers in preparation, seven submitted papers, four papers in review and two papers in press. Course participants published eleven papers directly influenced by this project's training. An additional four papers and a book published by PI's were supported by the award. Impact factors were available for 2014 and 2015 and seven of the eight papers were in high impact journals (impact factor ≥ 4). One paper was published in *Science* in 2014 which had an impact factor equal to 34. As of early August 2016 the six papers published in 2014 and 2015 were cited a total of 190 times. The paper in Science was cited 99 times.

No matter how skilled or confident participants felt at the end of the training they all learned what is involved in hierarchical Bayesian modeling, and were increasingly comfortable with Bayesian principles, appreciated the flexibility the methods have in developing custom models to fit research questions, and returned to their workplace more professionally well-rounded and informed.

Professional Affiliations of Respondents

Respondents reported their current professional affiliations in July 2016 which were grouped into general categories displayed below. Raw data and the classification categories used by this evaluation are included in Appendix B.

Professional Affiliation in July 2016	Number of Respondents
Community outreach center	1
Environmental organization	1
International government or university	6
University at a U.S. Territory	3
State government agency	7
U.S. government agency	10
U.S. university	43

Eleven of the 71 respondents changed affiliations since they completed this project's Bayesian training. Seven of these eleven respondents were postdoctoral researchers: three are currently in university positions (Puerto Rico, Michigan and Canada) as Assistant Professors and four of them moved to postdoctoral positions at different universities. One of the postdoctoral researchers that changed positions wrote, "I was hired for a postdoc position that requires Bayesian statistics. I can't overstate the benefit of this course to my research and career."

These are short synopses of changes in affiliations for the four respondents who were not postdoctoral researchers; they are identified as A, B, C and D:
- "A" was an assistant professor at an east coast university, moved to the West and is affiliated with a state university as a research assistant. "A" is also doing consulting.
- "B" was a research scientist at a private university in a U.S. territory and is currently a scientist with a government agency in the same territory.
- "C" was a scientist at a large city's botanical garden and is now an Assistant Professor and Extension Specialist at a state university.
- "D" is currently the director of an institute at a private Ivy League research university. Previous to this "D" was a research scientist at a state university.

Financial Considerations: Current and Future Stipends

Current Stipend Support

Participants were asked if they could have participated in the training course if the project had not provided a stipend. The responses were "yes", "no" or "maybe".

	Yes	No	Maybe
Number	18	32	21
Percent	25%	45%	30%
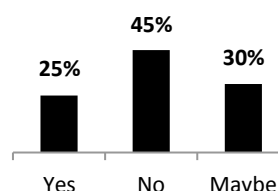
There wasn't a discernable common characteristic among the **eighteen respondents** who reported that they **would have been able to participate** in the training course if a stipend had not been provided. Three were from Colorado and the other fifteen were located in another country, twelve states and the District of Columbia, and were affiliated with government agencies and universities (one was a postdoc).

Thirty-two respondents indicated that they **would not have been able to participate** in the training course without a stipend. Eight of these 32 individuals recorded comments related to needing the stipend:
- No, I am a postdoc with a limited salary and financial instability.
- No, not at the time that I participated as I didn't have much additional travel support available.
- No- I did not have another source of funds to cover travel and lodging.
- No, it provided matched funding for my employer
- No, absolutely not. I was barely able to participate even with the stipend.
- No. As it is the expenses of the course not covered by the stipend were difficult to cover.
- No, unfortunately I could not. My limited travel funds are needed to support students.
- No, I never could have participated without the stipend. There was no way I could leave for the USA if there was no provision for the stipend which helped pay for a large part of my accommodation. The organizers were so considerate to help pay my stipend in cash to cater for the needs. I can never forget the gesture and how it has contributed to my capacity building.

Twenty-one respondents might have participated in the training course without a stipend but it depended on various circumstances. Two individuals lived in the same city as the training so they would have been able to participate without a stipend, but probably would not have participated in the training if they weren't living in the same city as the training. These were details shared by seven individuals:

- I could have participated, but having some extra money to fund the high costs of traveling from outside the US really helped in my decision to participate.

- I probably could have found the money elsewhere.

- Maybe, but the stipend gave me the incentive to actually apply for the course and attend it.

- Perhaps, but it would have been very challenging.

- The stipend really helped. I probably would have found a way to attend even without the travel award as this was important to me, but the award made things much easier. Of course, $1000 does not cover the entire cost of travel; it basically covered my housing while there for the 10 days. Airfare and my time to attend were covered by my own grants.

- This would have been difficult. As it stood, I ended up having to cover a good bit of the cost of my travel. Flexible funds are very difficult to come by, so covering the entire costs of the travel would have required me to use my personal funds. Especially now that I know how good the course is, I would have done this but many folks would not have been able to.

- Unlikely as I did not have other travel funds at the time. However, I would have done so with a smaller stipend that covered travel.

Future Stipend Support

Respondents answered the question, "What would the stipend need to be for you to attend a future training course?" Specific amounts recorded by eight respondents were: $2500 (one respondent), $2000 (3 respondents), $1200 (3 respondents) and $1500 (one respondent). Twenty-three (32%) of the 71 respondents indicated that the same amount as the current stipend would be needed to attend a future training course at the same location. (A change in location would likely require a higher stipend for air travel for some individuals.) The cost of air travel figured into the need for a higher stipend for fifteen (21%) of the respondents:

- I think the stipend level should the same or a little higher. It paid for my hotel and ground transportation but I covered the airfare on another grant.

- The stipend covered lodging but airfare, food and ground transportation were still on my own dime and costs were substantial.

- Maybe best to provide a standard housing stipend and then a flexible travel stipend to reflect the relative costs of getting to the workshop.

One individual wrote, "Other NSF-funded workshops to which I have been accepted covered costs 100% rather than providing a stipend."

The stipend did not apply to several of the individuals, one of whom explained, "I am a Federal employee and am unaware of a mechanism that would allow me to accept the stipend." One participant was concerned about the tax consequences associated with receiving a stipend instead of a reimbursement, "The stipend was paid as additional income which really complicated my taxes. I would have preferred a standard reimbursement."

The cost of lodging is also a consideration with the level received described as "adequate" by two individuals and another elaborated, "The hotel costs is the biggest concern, but I think I would do it again and pay my own way just to get a more comfortable room." A shared hotel room cost ~$60/day for one

individual. One individual wrote, "$1000 is good if very inexpensive housing could be provided for the entire time."

Comments about the Training

Comments by 51 respondents about the training (also referred to as "workshop" and "course") are in Appendix C. The overarching theme of the comments was that this training was outstanding; summed up by one individual as, "A++ for everything." An important feature of this well planned and organized training was that the gradational development of topics formed a cohesive, meaningful learning experience that made the material accessible to participants with a variety of statistical backgrounds. Understanding was enhanced because structure and time were provided for hands-on experiences during which participants reflected on concepts, strategies and issues. The background, experience, and expertise of the instructors contributed to the success of the training. These are three of the many favorable comments:

> This was by far the absolute best statistics course I have ever taken. The instructors' approach to the subject matter really helped develop a strong foundational understanding of the material and the rationale for how and why certain steps are performed. This is in contrast to other courses where we jump right into the coding and running of models and the students are left without a clear understanding of why they did what they just did and how to take what they just did and apply it to their own situations.

> This course was a career changer for me and I am extremely grateful to have had the opportunity to participate. The training was excellent – both during lectures as well as during the hands-on exercises. The networking was also extremely valuable.

> I cannot give the presenters and organizers of the workshop enough praise. I know the difficulties in presenting quantitative material in a clear and concise way. Their presentations, pace, and breadth of content was perfect. Could not have been a better experience.

Suggestions for improving the course included covering less material with more time for exercises, discussion, interpretation and troubleshooting; not going into as much theory; and fewer data sets for increased efficiency and clarity. One participant would have appreciated more practical examples and information related to population genetics. It would have been helpful to a couple of participants if relevant reading materials would have been made available prior to the course ("This would help prepare the would-be participants to grapple with the reality of what to expect, and prepare mentally for the intensive challenges of the workshop.")

As a result of this workshop participants reported increased skill and knowledge in applying Bayesian methods in their research, teaching, and research decision making. The course was described as transformative for a couple of participants with one of them noting that participating in the course changed "the way I think about problems and approach my science!"

Although several participants left the course feeling less than confident about their Bayesian modeling skills they felt the course was valuable to them and they have continued to work on understanding the topics better. It appeared that some participants might benefit from a second course where they could get support for increasing the depth of their understanding of the course topics and in developing their own models.

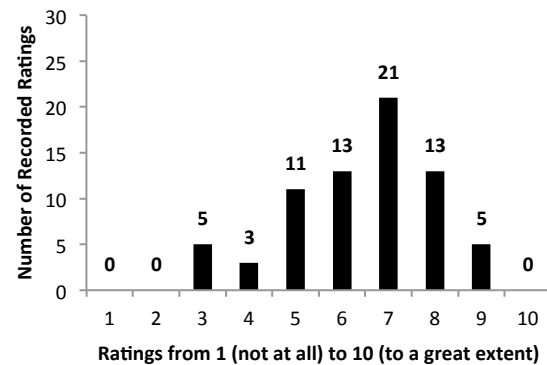# Self-Reported Levels of Expertise in Bayesian Analysis

Respondents were asked to retrospectively rate their level of **expertise for reviewing papers and proposals that use Bayesian analysis as part of their text** before and as a result of participating in the course. The rating scale was 1 (not at all) to 10 (to a great extent).

Charted frequency distributions and descriptive statistics of respondents' self-reported level of expertise for reviewing papers and proposals that use Bayesian analysis as part of their text before the workshop and after attending the workshop are displayed in the following tables and charts. Matched pair (dependent) t-test and effect size (Cohen[1]) were used in the analysis of these pre/post ratings.

Level of Expertise in Using Bayesian Analysis in Reviewing Papers and Proposals Before the Course
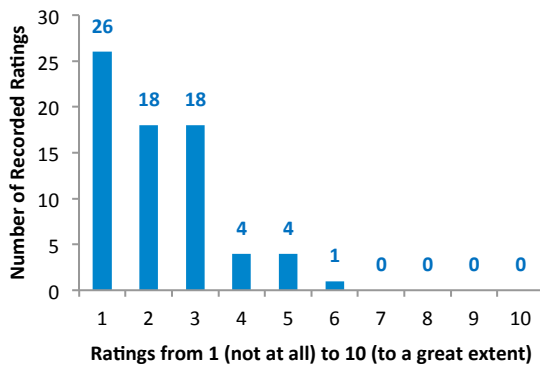
Level of Expertise in Using Bayesian Analysis in Reviewing Papers and Proposals After the Course

Mean ($\bar{x}$), standard deviation (SD), correlation coefficient (r), t-statistic, and p-value for levels of expertise for reviewing papers and proposals that use Bayesian analysis as part of their text are displayed in the table below. Based on these recorded ratings the workshop had a large effect (effect size 2.92) on increasing this expertise.

Pre- and Post-training Statistics

Expertise	N	$\bar{x}$	SD	r	t	p <	Effect size
Before the Course	71	2.22	1.24	0.49	24.39	0.0000	Large 2.92
After the Course	71	6.42	1.57				

Project Outputs (Products)

Twelve possible outputs (products) were listed on the questionnaire and respondents recorded "Yes" if the listed product was influenced or shaped by their participation in this project. Space was also provided for "other products" influenced or shaped by participation in the project.

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[1] Cohen, J. (1988), *Statistical Power Analysis for the Behavioral Sciences, 2nd Edition.* Hillsdale, N.J.: Lawrence Erlbaum.

Numbers of respondents who credited the training with influencing or shaping each of these outputs are listed in the following table: e.g., 16 respondents reported new courses (they taught, developed, or enrolled in) that were influenced or shaped by their participation in this project's training course.

Outputs/Products Influenced or Shaped by the Training

Description of Type of Output (Product)	Number "Yes"
New courses	16
Modified courses	27
Published paper/s in peer-reviewed journals	40[2]
Published monograph/s	4
Published book or book chapter/s	2
PI, Co-PI or major contributor in submitted proposal	30
PI, Co-PI or major contributor in awarded NSF grant	4
PI, Co-PI or major contributor in grants from other NSF agencies	14
Technical reports supporting policy and/or management	14
Dissertation/s	11
Thesis/es	6
Workshops	13
Other products	8

Other products included presentations (one of the presentations was titled *A Brief Introduction to Bayesian Modeling for ecologists: A Novice Perspective*), technical consulting to graduate students, a graduate course that has motivated Bayesian approaches in doctoral research, handling of manuscripts as an associate editor, development of a Bayesian model to quantify hydrologic alteration and reviewing manuscripts and proposals.

New Courses

The sixteen respondents described details about new courses that were influenced or shaped by their participation in this project's training: **five new courses were developed, six new courses are in the process of being developed, three individuals will teach courses that include Bayesian topics for the first time, and two individuals are planning to participate in additional Bayesian topics** professional development. These were their comments:

1. Bayesian Modeling is part of a new graduate course, "Analyzing Ecological Data", first taught to 17 doctoral students in 2015 before being approved as a permanent course, taught again in 2016
2. Developed a new graduate statistics course drawing broadly from this material
3. I am developing a course in quantitative ecology for graduate students in my department and will include an introduction to Bayesian modeling as a two week primer on the subject. I may also take over instruction of our department's Bayesian course.
4. I am planning on Teaching a "Bayesian Modeling in Ecology" course within 2 years
5. I am planning on teaching a similar, but slightly 'lower-level' version of the workshop in January, 2017.

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[2] Includes approximately 12 papers in preparation, 7 submitted, 4 in review and one in press

6. I am planning to do a graduate seminar on the material presented in this course
7. I developed a graduate course on Quantitative Biology
8. I started a new class on Statistics that included an introduction Bayesian approaches
9. I taught a graduate course on Bayesian Methods in Ecology
10. I will be taking another course at the American Fisheries Society Annual Meeting
11. I will be teaching a new course in Fall 2016 titled "Likelihood and Bayesian Ecology"
12. I'm now looking for new opportunities to expand my knowledge of Bayesian modeling
13. Incorporated aspects of training into a Topics in Marine Biology: Fisheries Science and Management graduate seminar
14. Teaching a graduate Bayesian course at my university in Fall 2016
15. Want to establish new Bayesian course
16. Will begin to offer short courses locally

Modified Courses

Twenty-five respondents provided details about courses they modified, are currently modifying, or plan to modify as a result of participating in this project. **Eighteen respondents modified or are currently modifying courses, six respondents plan to modify courses and one may modify an existing quantitative course.** These were their comments:
1. Added basic Bayesian techniques to graduate marine science course in statistics
2. Added more Bayesian component in the ecological modeling course
3. I added a Bayesian analysis module, including laboratory exercises, to my existing Data Analysis course for graduate students at UAF (~12 students/year)
4. I am modifying my "Ecological Statistics with R" course to include two weeks on "Introduction to Bayesian Modeling"
5. I am revising my existing graduate course in data analysis to include the basics of Bayesian methods as a primer for the following graduate seminar described above
6. I began redesigning my graduate level quantitative ecology course
7. I have offered graduate seminars influenced by the course; we are currently doing a reading group of Gelman & Hill's book *Data Analysis Using Regression and Multilevel/Hierarchical Models*.
8. I include basic Bayesian methods in my graduate statistics course
9. I intend to include a section on Bayesian geospatial modeling in my landscape ecology course.
10. I plan to modify my graduate statistics course to introduce students to Bayesian approaches
11. I teach Numerical Ecology to postgraduate students. The training in R has greatly helped improve my course delivery and the assistance I render to students regarding statistical analyses of their research.
12. I will be modifying some of my senior classes in 'modeling and estimation' as a direct result of the course.
13. I will incorporate Bayesian Methods, an expanded probability section, and moment matching (with extensive description of frequency distributions) into my graduate-level statistics class that I teach annually.
14. I include discussion of Bayesian methods in graduate courses.
15. I included Bayesian analysis in BIOL 458 Quantitative Ecology
16. I may modify my existing quantitative courses.
17. Inclusion of Bayesian procedures in upper-level courses

18. Incorporated aspects of training into "Introduction to Quantitative Fisheries Science" graduate course
19. Incorporation into advanced undergraduate instruction
20. Introduced Bayesian methods into an existing course on data analysis in R
21. Modified one of my graduate courses
22. Now I include Bayesian "thinking" in all my courses
23. This course has fundamentally changed how I think about quantitative methods and thus how I will teach my quantitative courses.
24. Will add Bayesian ideas to existing course
25. Working with my post doc advisor to modify his graduate statistics course to include Bayesian perspective

Workshops

Thirteen individuals reported activities associated with developing and/or implementing workshops that include Bayesian statistics. Respondents reported feeling more confident discussing Bayesian approaches in existing workshops. The influence of the course was evident in that eight existing workshops that deal with topics like estimation, metagenomics, and R will now include Bayesian methods and tools (e.g., JAGS).

These are descriptions of new workshops in various stages of planning and development that respondents credited to attending the project's workshop:

- Entire new workshop series underway at the agency as a result of the workshop.

- Currently leading a working group funded by an RCN project that will incorporate some Bayesian principles (i.e., multivariate auto-regressive state space models)

- I am planning to do a workshop covering the material in this course for members of my lab and my collaborator.

- I am considering organizing a Bayes workshop at (a state) conference that my organization is hosting next December.

- I have begun organizing a series of half-day workshops on the course materials to disseminate the knowledge I learned to my colleagues.

- I have been invited three times for the OTS course to give a workshop on modeling. I always include a Bayesian component.

- I participated recently (two weeks ago) in a workshop on statistical analyses using R. My knowledge helped me guide participants in the flexibility of use of R in analyzing research data

- The design of an R workshop that includes tools for Bayesian analysis.

Publications

Forty individuals responded, "Yes" when asked if their participation in the project influenced or shaped published papers in peer reviewed journals. In addition to realized publications respondents reported twelve papers in preparation, seven submitted papers, four papers in review[3] and two papers in press. Ways participation in the course influenced scientific research papers were described by four individuals: their papers included strong Bayesian components; Bayesian analysis of exam and educational research

[3] A fifth paper co-authored by the PI is also under review: Ketz AC, Johnson TL, Monello RJ and Hobbs NT. Informing management with monitoring data: the value of Bayesian forecasting, Ecosphere

data; Bayesian modeling estimating colonization dynamics and abundance of sea otters; and analysis of data sets using Bayesian hierarchical modeling. One respondent described the influence of the course on research papers more generally, "It has helped me to increase the statistical rigor of published papers." Eight individuals said that although they had not published a paper that included Bayesian statistics they intend to incorporate Bayesian approaches in future manuscripts. At least one book and four papers will be updated to account for what was learned in the course.

Information about published papers was reported by survey respondents and in emails separate from the survey. They are included here along with the publications reported on the survey.

Peer-reviewed Journal Publications: Impact Factors and Citations

Citation data were collected on August 5, 6 and 7, 2016 from Google Scholar. Thomson Reuters impact factors were accessed from Web of Science; 2016 impact factors will not be available until 2017.

Course participants published eleven papers directly influenced by this project's training. An additional four papers and a book published by PI's were supported by the award. Impact factors were available for eight papers (2016 impact factors will be available in 2017); seven of the eight papers were in high impact journals (impact factor ≥ 4). One paper was published in Science in 2014 which had an impact factor equal to 34.

As of early August 2016 the eight papers published in 2014 and 2015 were cited a total of 194 times. The paper in Science was cited 99 times.

Peer-reviewed Journal Publications and Books that Acknowledged this Grant

2016 Campbell EE, Parton WJ, Soong JL, Paustian K, **Hobbs NT**, and Cotrufo MF (September 2016). *Using litter chemistry controls on microbial processes to partition litter carbon fluxes with the Litter Decomposition and Leaching (LIDEL) model*, Soil Biology and Biochemistry, 100: 160-174
>   NOTE: This paper is online with a publication date of September 2016.

2016 **Wilson RR**, Regehr EV, Rode KD & St. Martin M (2016). *Invariant polar bear habitat selection during a period of sea ice loss*, Proceedings of the Royal Society B, 283 (1836); DOI: 10.1098/rspb.2016.0380
>   NOTE: This was published on August 17, 2016.

2014 **Carrillo-Rubio E**, Kery M, Morreale S J, Sullivan P J, Gardner B, Cooch E G & Lassoie J P (2014) *Use of Multispecies Occupancy Models to Evaluate the Response of Bird Communities to Forest Degradation Associated with Logging*, Conservation Biology, 28(4): 1034-44.
>   NOTE: This article was cited seven times as of 8/5/2016; the 2014 journal impact factor was 4.26.

2016 Harris JBC, **Tingley MW**, Hua F,Yong DL, Adeney JM, Lee TM, Marthy W, Prawiradilaga DM, Sekercioglu CH, Suyadi, Winarmi N and Wilcove DS (2016). *Measuring the impact of the pet trade on Indonesian birds*, Conservation Biology (online early). doi: 10.1111/cobi.12729 [link]
>   NOTE: This publication acknowledged support from NSF grant #1145200 but entered a wrong award number (#000347455) in the acknowledgement.

2015 **Hobbs NT** and **Hooten MB** (2015). *Bayesian models: a statistical primer for ecologists*, Princeton University Press, Princeton, N.J.

2015 Hooten MB and **Hobbs NT** (February 2015). *A guide to Bayesian model selection for ecologists*, Ecological Monographs, 85(1): 3-28
>   NOTE: This article was cited 73 times as of 8/5/2016; the 2015 impact factor of this journal was 6.98. Dr. Hooten is a Co-PI and Dr. Hobbs is the PI on this project. This publication acknowledged support from NSF grant #1145200 but entered a wrong award number (#000347455) in the acknowledgement.

2015 Raiho A M, **Hooten MB**, Bates S and **Hobbs NT** (2015). *Forecasting the effects of fertility control on overabundant ungulates: White-tailed deer in the National Capital Region*, PLoS ONE, 10(12): e0143122
>   NOTE: Cited one time; 2015 impact factor of PloS ONE was 3.54.

2015 Hobbs NT, Geremia C, Treanor J, Wallen R, White PJ, **Hooten MB**, and Rhyan JC (2015). *State-space modeling to support management of brucellosis in the Yellowstone bison population*, Ecological Monographs, 85:3-28
>   NOTE: This was cited three times. The 2015 impact factor of the journal was 6.98.

Peer-Reviewed Publications that Were Influenced by the Training

2016 Bright AJ, C Rogers, **M Brandt**, E Muller and TB Smith (May 24, 2016). *Disease prevalence and snail predation associated with swell-generated damage on the threatened coral*, Acropora palmata *(Lamarck),* Frontiers in Marine Science, http://dx.doi.org/10.3389/fmars.2016.00077
>   NOTE: It has been cited once.

2015 Christie KS, Jensen WF, Schmidt JH and Boyce MS (2015). *Long-term changes in pronghorn abundance index linked to climate and oil development in North Dakota*, Biological Conservation, 192: 445-453.
>   NOTE: Bayesian mixed-effects models were used to analyze variation in annual population count data relative to weather conditions, coyote populations, oil and gas development, human harvest, and agricultural practices. The 2015 impact factor of the journal was 3.99, and the 2015 five-year impact factor was 4.75. This paper was cited once.

2016 Elmendorf SC, Jones KD, Cook BI, Diez JM, Enquist CAF, Hufft RA, Jones MO, Mazer SJ, Miller-Rushing AJ, Moore DJP, Schwartz MD and Weltzin JF (2016). *The plant phenology monitoring design for The National Ecological Observatory Network*, Ecosphere 7(4):e01303. 10.1002/ecs2.1303
>   NOTE: Discussed using Bayesian hierarchical models in community phenology forecasting.

2015 Cavender-Bares J, González-Rodríguez A, Eaton DAR, Hipp AAL, Beulke A and Manos PS (2015). *Phylogeny and biogeography of the American live oaks (*Quercus *subsection* Virentes*): a genomic and population genetics approach*, Molecular Ecology, 24: 3668–3687. doi:10.1111/mec.13269
>   NOTE: Used the Bayesian program BEAST which allows time calibration of nodes in a phylogeny. 2015 impact factor was 5.95; paper has been cited 6 times.

2016 Anderson TM, White S, Davis B, Erhardt R, Palmer M, Swanson A, Kolmasa AM and Packer C (2016 in press). *Spatial distribution of African savannah herbivores: species associations and habitat occupancy in a landscape context,* Philosophical Transactions of the Royal Society – Series B.
>   NOTE: Includes a Bayesian occupancy model for savanna ungulates based on camera trapping.

2014 Holdo RM, **Anderson TM** and Morrison T (2014). *Precipitation, fire and shifting demographic bottlenecks in Serengeti tree populations*, Landscape Ecology 29:1613-1623.

NOTE: Used Bayesian statistics. The 2014 impact factor of the journal was 4.38; this paper was cited four times.

2014 Lehmann C, **Anderson TM**, Sankaran M, Higgins SI, Archibald S, Hoffmann WA, Hanan NP, Williams RJ, Fensham R, Felfili J, Hutley L, Ratnam J, San Jose J, Montes R, Franklin D, Russell-Smith J, Ryan CM, Durigan G, Hiernaux P, Haidar R, Bowman DMJS and Bond WJ (2014). *Savanna vegetation-fire-climate relationships differ among continents*, Science, 343: 548-552.
      NOTE: Used Bayesian method in analyzing data. The 2014 impact factor of the journal was 33.61; this paper was cited 99 times.

2016 Jackson JA, **Carroll EL**, Smith TD, Zerbini AN, Patenaude NJ and Baker CS (March 2016). *An integrated approach to historical population assessment of the great whales: case of the New Zealand southern right whale*, Royal Society Open Science, 3(3): 150669
      NOTE: Used a Bayesian population dynamics model integrating multiple data sources: nineteenth century catches, genetic constraints on bottleneck size and individual sightings histories informing abundance and trend.

Technical Reports Supporting Policy and/or Management

Fourteen respondents indicated that their technical reports supporting policy and/or management were influenced by their participation in this project's course although three of them were anticipated future reports ("Plan to use Bayesian methods for several upcoming management reports.") These were the descriptions offered by eleven individuals:

1. Analyses for agencies on nest survival
2. Developed a Bayesian population viability model that is being used to inform management of threatened Lahontan cutthroat trout
3. I plan to include Bayesian approaches in future technical reports on freshwater fisheries conservation and management.
4. Moved me from simple application to understanding
5. Multiple reports for the USDA Forest Service include analyses that benefitted from the training from this course
6. Review Bayesian stock assessment models for Western Pacific Regional Fishery Management Council
7. This course has allowed me to address management questions that would not have been possible previously, greatly increasing the relevance of the work coming out of our office.
8. We are still collecting date but intend on using Bayesian methods in the analysis
9. Will explore Bayesian analyses for certain projects
10. Will use Bayesian methods for future demographic analyses for polar bears that are used to inform management and conservation categorization (e.g., IUCN Red List Assessment)
11. Yes, increased opportunity to use Bayes methods in reports related to fisheries management.

Dissertations and Theses

Eleven respondents reported that the training influenced dissertations. Six dissertations were reported as using Bayesian statistics three of which were described: 1) modeling mesophotic coral distributions, 2) studying snapping turtle harvest, and 3) analyzing bird survival, recruitment and abundance in two habitats. Three other dissertations using Bayesian methods are in progress. These were six remarks about other ways the course has influenced participants with regard to dissertations:

- My graduate students could use Bayesian statistics in their thesis/dissertation, pending completion of our fall 2016 Bayesian graduate course.
- I feel more qualified to advise dissertation work using these methods.
- Bayesian methods I have taught to grad students are already being used in dissertations.
- I am now evaluating the appropriateness of modifying students' theses to operate within the Bayesian framework. This applies to both MSc and PhD students.
- Understanding of a dissertation as committee member
- Helped guide a student's dissertation which incorporated spatial Bayesian methods

Four of the individuals who reported the influence of the course on dissertations also reported the same influence on theses. One respondent wrote in detail about an MS candidate's thesis:
- The student is using a Bayesian hierarchical model to investigate temporal patterns of fish growth. We are working to add this model to his plan of inquiry using the tools obtained in the workshop (RJAGS and DAGs).

PI, Co-PI or Major Contributor to Awarded and not-Awarded Proposals

The influence of the course on grant proposals was reported by thirty respondents, and eighteen respondents reported influences on awarded grants. Numbers of proposals and grants specifically identified are displayed in the table below.

Identified Proposals and Awarded Grants

Number of Proposals		Number of Grants Awarded	
NSF Proposals	Other Proposals	NSF Grants	Other Grants
8	6	2 (CAREER and DEB)	5

These were descriptions of ways the course influenced participants seeking external funding but without specific information about the proposal or grant:
1. Adding analyses to proposal
2. Bayesian statistics is an central part of the experimental design of my current research proposals
3. Have proposed using methods from this course in several proposals.
4. Have submitted multiple proposals. Although nothing is seriously related, all my proposals are now basically Bayesian.
5. I am going to be using this analysis on projects I am working on now
6. I have included Bayesian models in grant proposals
7. I hope to apply what I have learned in future efforts.
8. I just attended this workshop but intend to include what I learned in future proposal
9. Inclusion of Bayesian procedures, and formal likelihood statements, in multiple research proposals
10. Influenced several proposals submitted to NSF and other agencies.
11. PI and contributor on submitted proposals that use Bayesian modeling
12. Plan to propose Bayesian analyses in an upcoming proposal
13. Revising proposal based on course material
14. This is too early but I am working on an NSF proposal that now includes Bayesian tools

15. Will expand on ideas in proposal
16. Work proposed is only possible based on the knowledge I gained from this course.
17. Yes, looking to use Bayes approaches in upcoming submitted proposals, some to NSF.

Additional Comments about Products/Outputs

Eight respondents who recorded comments about the products/outputs completed the course only two weeks before the questionnaire was sent to them so although they did not have time to generate "Bayesian outputs" they all plan to do so in the future. Three respondents praised the workshop; one wrote, "I think the basic premise of the grant supporting the course ('teach the teachers') was absolutely met at all levels. The instructors were all expert, at both the material, and the instruction of same, and attending the course was like a musician attending a 'master class'." The other twenty-eight comments emphasized the importance of what they learned at the workshop to their professional careers and the careers of the individuals they mentor. These are five comments that were unique in the topics they addressed:

Problem-based Critical Thinking: This course fundamentally changed how I think about quantitative methods and the scientific method more generally and thus have positively influenced my scholarship and teaching. The long-term influences are difficult to predict and specify, but should not be dismissed.

Long-term Engagement: I will be employing Bayesian approaches to analysis of my own data, and that of my doctoral students, in the near future (already collected data). The 2014 workshop plus teaching a 3-4 week unit on Bayesian Modeling to doctoral students twice since I took the workshop has now made it possible for me to apply Bayesian analysis with confidence. I could not have incorporated a section on Bayesian Modeling into my new graduate course if I had not taken the NSF-sponsored workshop.

Expanded Impact: As a result of this training, I am directly including two weeks of "intro to Bayesian modeling" in an existing graduate level "ecological statistics" course, and also preparing a new course on "Bayesian modeling with R" in the coming years. I have been updating some of my manuscripts to use a Bayesian modeling plan to offer a short two-day workshop at another university in July 2016 and another 2-5 day workshop to students and faculty in my department August-September 2016. I am including Bayesian modeling in my upcoming NSF proposal.

Foster a Learning Community: Since I attended the first course, two other faculty from (university) have attended the CSU course, my former graduate student has attended the SESYNC course, and two postdocs I collaborate with will attend the SESYNC course this year. I strongly believe that the courses are changing the available expertise in ecology.

Increased Analytical Capacity: Prior to this class, I was asked if I would be able to analyze a very messy data of fall observations of polar bears along a coastal survey trajectory. I was at a loss as to how to conduct this analysis given the complexity of the data set (e.g., inconsistent sampling, missing data, etc.). However, immediately after completing the course, I could see a path forward on how to build my own model to overcome the analytical issues that were impossible with the methods I had previously been capable of employing.

Most Important Insights Gained from the Training

The most important insights participants reported reflected the anticipated learning outcomes of the project which were to 1) explain key principles of Bayesian statistics, 2) use basic statistical distributions in hierarchical Bayesian models, 3) use Markov Chain Monte Carlo methods, 4) understand and use JAGS and R software, 5) develop and implement hierarchical models, and 6) evaluate strength of evidence in alternative models for ecological processes.

Participants learned that the hierarchical Bayesian modelling approach is a very powerful and flexible tool for understanding ecological data. Learning the key principles of Bayesian statistics, "the simple and elegant logic of it", and the breadth of analysis possible when employing Bayesian approaches removed any doubts participants might have had about using Bayesian modeling to analyze their complex research data ("This class provided a complete paradigm shift on how I think about data analysis, moving from trying to find a test that would work best to answer my question, to now thinking about how the data are structured and what types of information can be extracted from the data. It's a much more enlightening, motivating, and satisfactory approach and has increased the quality of my work substantially.) Participants gained a solid foundation in basic probability, learned how Bayesian methods can handle all kinds of data, how useful Bayesian methods can be for evaluating the impacts of different management alternatives, and how to properly formalize statistical models and discuss them.

Learning the underlying theory and the process of drawing out a diagram and writing out the full conditionals before starting to code made the process more intuitive and explainable. Being able to write down data analysis in equation form and draw its DAG was a critical point for many of the participants. Through hands-on experiences participants gained understanding of how to visualize and implement reasonable data analysis for complex data. ("My eyes were opened to the possibilities of using prior information, borrowing strength across different data sets that could be combined into one model, and being more intentional about probability distributions I use in my analysis.")

Participants described being amazed by how very complex Bayesian models can emerge from the simple principles of conditional probability, joint probability and total probability, and how a complex model can be partitioned into simple manageable chunks. ("I learned that by mastering just a handful of principles [e.g., probability distributions] I could successfully and independently implement Bayesian approaches in my research.")

Participants learned how to use Markov chain Monte Carlo methods and to write algorithms and computer code in R. Learning how to use R and JAGS software was especially significant to many of the participants. They learned how to handle data beyond the "regular" statistical packages they had been using. ("I need not be constrained by frequentist statistics and arbitrary p-values.") The emphasis on understanding versus rote application was an important outcome of the course ("Quite importantly, I gained understanding of the serious pitfalls of uncritical, cavalier application of Bayesian modeling -- which is a real possibility given the availability of R code to run the simpler Bayesian analyses.") They learned to think critically about Bayesian modeling and methods.

No matter how skilled or confident participants felt at the end of the training they all learned what is involved in hierarchical Bayesian modeling and analysis. ("I learned enough about Bayesian modeling to have a discussion or provide basic feedback when evaluating a manuscript / proposal. I did not learn enough to use these techniques independently.") After the training participants were increasingly comfortable with Bayesian principles, appreciated the flexibility the methods have in developing custom models to fit research questions, and returned to their workplace more professionally well-rounded and informed.

Appendix A: Locations of Trainees in U.S. States

Locations of U.S. Project Participants (Shaded in red)
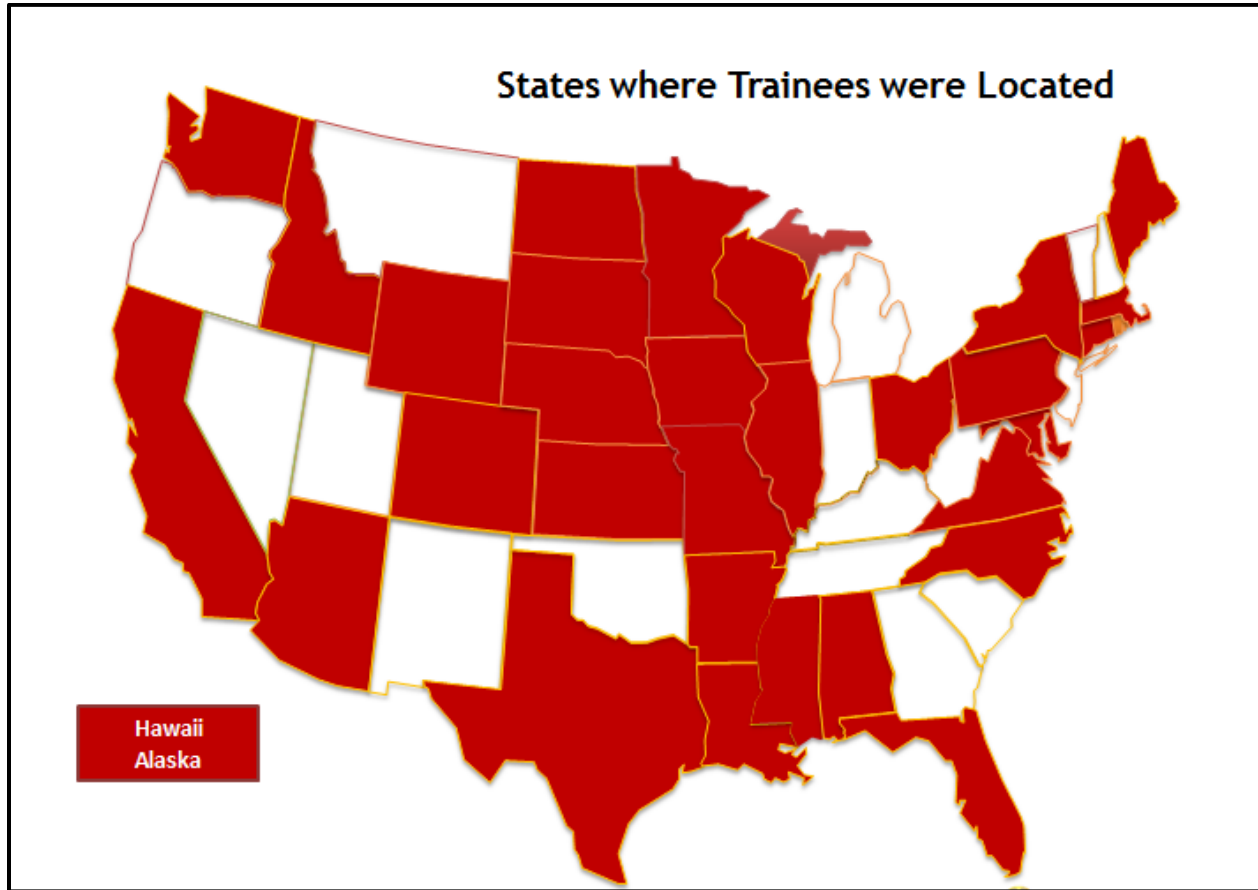
State	# of Trainees
Alabama	1
Alaska	6
Arizona	1
Arkansas	1
California	5
Colorado	7
Connecticut	1
Delaware	1
Florida	4
Hawaii	4
Idaho	1
Illinois	3
Iowa	1
Kansas	1
Louisiana	1
Maine	1
Maryland	2

State	# of Trainees
Massachusetts	2
Minnesota	2
Mississippi	3
Missouri	1
Nebraska	1
New York	2
North Carolina	1
North Dakota	2
Ohio	3
Pennsylvania	2
South Dakota	1
Texas	1
Virginia	4
Washington DC	1
Wisconsin	1
Wyoming	1

Appendix B: Current Professional Affiliation Raw and Category Data

Current Professional Affiliation	Category determined by Evaluator
Prince William Sound Science Center	Community research center
The Nature Conservancy	Environmental organization
INDICASAT-AIP	Intl Government organization
University of Queensland	Intl University
University of St Andrews	Intl University
CREAF, Barcelona, Spain	Intl University
University of Ibadan, Ibadan, Nigeria	Intl University
University of Melbourne	Intl University
University of Puerto Rico	US Territory University
University of Puerto Rico	US Territory University
University of the Virgin Islands	US Territory University
National Ecological Observatory Network	NSF (US Govt)
National Ecological Observatory Network	NSF (US Govt)
National Ecological Observatory Network	NSF (US Govt)
Alaska Department of Fish and Game	State
Alaska Sea Life Center	State
Arizona Game & Fish Department	State
Colorado Parks & Wildlife	State
Florida Fish & Wildlife Conservation Commission	State
National Park Service, Alaska	State
Texas Parks & Wildlife Department	State
California State University at Northridge	University
Chatham University	University
Concordia University	University
Cornell University	University
University of Wisconsin	University
Iowa State University	University
Kansas State University	University
Kent State University	University
Mississippi State University	University
Ohio State University	University
Pennsylvania State University	University
Radford University	University
University of Alabama	University
University of Alaska Fairbanks	University
University of Central Florida	University
University of Connecticut	University
University of Florida	University

University of Georgia	University
University of Hawaii	University
University of Hawaii	University
University of Hawaii	University
University of Hawaii at Manoa	University
University of Illinois at Chicago	University
University of Illinois at Urbana	University
University of Massachusetts	University
University of Michigan	University
University of Minnesota	University
University of Minnesota	University
University of Minnesota	University
University of Montana	University
University of Nebraska	University
University of North Dakota	University
University of South Dakota	University
University of Southern Mississippi	University
University of Southern Mississippi	University
University of Waterloo	University
University of Waterloo	University
University of Wyoming	University
University of Wyoming	University
Virginia Commonwealth University	University
Wake Forest University	University
Washington State University	University
Yale School of Forestry	University
National Park Service	US Govt
U.S. Fish and Wildlife Service	US Govt
U.S. Fish and Wildlife Service	US Govt
US Geological Survey	US Govt
USDA Forest Service PSW	US Govt
USGS	US Govt
USGS	US Govt

Appendix C: Comments about the Training

The comments were edited to remove identifying information. Spelling was corrected appropriately.
NOTE: The training is also referred as a course and as a workshop.

1. A well-executed workshop and a great service to the community. Although I have not applied these methods to my own work to the extent I had hoped, I am grateful for the opportunity to advance my understanding of these tools. I have advocated their use to others in my program.

2. A++ for everything. My suggestions are largely driven by what I imagine I will take from the class for my own teaching. The basic 'balance' points over an 8-9 class are different than if you have many more days to flesh out the material. I suspect the main thing I'd do is take a more leisurely stroll introducing the 'lab mechanics', and start with a series of simpler examples than were presented. This is in no way a criticism of the course -- the people taking the course were all fairly 'senior/advanced', and I thought the level/pitch/pacing was entirely appropriate (even tour de force bits of algebra on the whiteboard were accessible -- mostly!). My perspective is filtered through the types of students I will be working with, who will have significantly less background than the people taking this course.

3. All instructors were excellent. I really appreciated that they took the initiative to make this material accessible to so many. This is an excellent example of NSF funds being used in creative and highly appropriate ways. Well done - you are inspirational to me!

4. Bayesian modeling for practicing ecologists was the best short course that I've taken in 10 years. The step-by-step development of the topic and expertise of the instructors made the material easy to follow and provided actual skills to take back for my teaching and research.

5. Covering less material but having even more time for exercises, discussion, interpretation, troubleshooting... all the skills people need to do this on their own, would be valuable. I know the temptation to cover lots of ground, given that any particular sub-topic (especially beyond the very basics) will only interest some people... but I think just more practice with simple but full analyses (start to finish) would be stellar. Part of training is building confidence, especially for a topic like this. All that being said, this workshop was very well done and I appreciate the experience quite a bit.

6. Even though I took the course in 2013, I am just beginning to fully implement the objectives of the course, like starting a course at my university. This may already exist, because I'm just starting to look for it. But it would be great to have a forum/mechanism for ongoing support/discussion for a long period after the training.

7. Fewer data sets would have led to less confusion and more efficiency.

8. Great course - keep up the great work!!

9. Great course! Knowledgeable instructors! Well organized!

10. Great course. Learned a lot. Only reason not incorporated into products thus far is job change and amount of time needed to do so.

11. (Names) are wonderful educators. Dr. Hobbs, in particular, is excellent and should be commended.

12. I am very glad I attended the workshop. Everyone was very knowledgeable and I learned a lot more than I thought I would. I have even retained a lot even though I have yet to use it actively. I have also recommended the workshop to others

13. I cannot give the presenters and organizers of the workshop enough praise. I know the difficulties in presenting quantitative material in a clear and concise way. Their presentations, pace, and breadth of content was perfect. Could not have been a better experience.

14. I can't say enough how useful this course was to me.

15. I feel very lucky to have had the opportunity to take this course. I had tried learning the techniques on my own a number of times with limited success. The course instructors and format made the material accessible and relatable. By the middle of the second day, I already understood the foundations of Bayesian methods. My understanding and enthusiasm continued to increase over the course. I felt and feel incredibly empowered by the material and its applications to my work and my students' work. These techniques allow researchers to thoughtfully, clearly and robustly tackle an unlimited number of research hypotheses - the "doing" of science in a transparent and useful way. This is the core of the scientific method. Because of this course, I am empowered to use these techniques in my own work. In addition (and as importantly), the instructors' care in teaching the material has given me the confidence to pass on these skills to my students. I very much appreciate their immense time and effort in the course preparation and delivery. I hope this course can run for many years and many others can benefit from it.

16. I planned to do more with the training, including adding a new course; I still plan to do this in the future. It was a fantastic course and I very much enjoyed working with the teachers and my classmates.

17. I really enjoyed this workshop, the instructors, and the other participants. Lots of really bright people asking great questions and having "Eureka!" moments again and again. The instructors were all fantastic, too. My only regret was I had to leave early on the last day and did not have much time to work on my independent project, which I think would have greatly benefited me and cemented some of the ideas that were developed in the workshop. I know time is tight, but perhaps having short (30-45 minute) sessions every other day throughout to develop your project idea and move it along incrementally as you learn the bits and pieces of Bayesian modelling would be an option. Overall, though, an absolutely fantastic workshop that has fundamentally changed the way I think about problems and approach my science!

18. I really learned a great deal from the course, but I have been frustrated that I am not yet comfortable enough to apply the tools and develop my own models. I just need more practice and am not sure where to get additional training.

19. For the vast majority of us, I think, the impact of the course will take some time.

20. I was thoroughly confused during the course, but am grateful for it. I can now analyze most of my work in a Bayesian fashion, though it took a good deal of self-teaching. The course prepared me for that.

21. In a few years, let me know if you need another instructor! ;-)

22. It was a fantastic course. The instructors were knowledgeable and I loved the structure of the training, from theory to practice.

23. It was a great workshop. The speakers were excellent and the material has consistently provided a valuable resource. My only complaint is that I do population genetics and having more practical examples and information relating to this field would have been good e.g. learning that dirichlet distributions are used to model allele frequencies.

24. It was a long and challenging workshop but it definitely got me started with including Bayesian modeling in my work. I am entirely convinced that without this workshop I wouldn't have gotten started on learning these tools.

25. It's much easier to justify going to a workshop when there is a stipend attached, particularly because my supervisors are even less familiar with Bayesian methods than I am and they often don't see the relevance of exploring newer methodologies or facing the uncertainty of seeing an immediate return on investments for this kind of workshop. Though many of the lectures and exercises were beyond my expertise or experience to follow completely, I'm happy now that I understand conceptually what goes into Bayesian modeling and have seen where it can be applied in our agency and in our research.

26. Overall, an excellent course with great instructors.

27. Please keep offering this! I think it is an incredibly important resource and I have directed half a dozen people to apply over the years.

28. Please keep these courses going. They have been tremendously helpful to all involved and I have never seen another course offered that provides professionals with this level of information!

29. Thanks to all for the experience

30. The course has provided a very solid foundation for continued learning. I feel comfortable exploring these concepts in further detail on my own and beginning to teach them to others (which I did not feel comfortable with at all prior to the course).

31. The course was an excellent experience. thanks

32. The course was fantastic! I learned so much, and made great connections with smart people.

33. The course was fantastic. I enjoyed the structure, although the instructors perhaps went a bit too deep into the theory at times (I can forgive them for this because I think I do this with my own students on a daily basis!). While I didn't come out of the course feeling confident in my abilities, I continued to try my hand at Bayesian analyses in my and my student's research, going back to the course materials on a daily basis. I soon realized that, with the course materials, including the book manuscript, I knew enough for self-learning to take me the rest of the way. This course was well worth my time and I am certain I will continue to incorporate Bayesian techniques in my research, teach my graduate student Bayesian techniques, and I hope to incorporate some aspects of Bayesian analyses into my graduate course in Population Ecology. Thanks for a fun and stimulating 10 days in Fort Collins!

34. The course was tough for me because I was on the lower end of expertise in R and statistics, but I learned a lot and the materials provided give me a chance to work through the exercises on my own time.

35. The organizers could circulate a few relevant reading materials to accepted participants before the workshop, online or by postal services. This would help prepare the would-be participants to better grapple with the reality of what to expect, and prepare mentally for the intensive challenges of the workshop. It is a great workshop, very relevant to today's research challenges. Please don't stop organizing and supporting it. Thank you.

36. I can't overstate the benefit of this course to my research and career. Not to mention the personal satisfaction of being able to develop customized and robust statistical tools for conservation.

37. This course was a career changer for me and I am extremely grateful to have had the opportunity to participate. The training was excellent - both during lectures as well as during the hands-on exercises. The networking was also extremely valuable.

38. This course was an excellent introduction to Bayesian modeling that fulfilled its purpose perfectly. It was both an introduction, but also provided a lot of substantive detail about the theory and practice of implementing a Bayesian model. The course was well thought out in the context of accelerating one's own learning after the course. They really thought this through well. I feel my learning was greatly accelerated and I am in a position to move forward on my own. All in all, this was a super-wise investment of National Science Foundation funds!

39. This course was excellent, and I hope it continues to be offered in future years. I will highly recommend it to colleagues.

40. This was a theoretically eye-opening, practical, and challenging course. It was especially challenging given the short duration. But given the busy schedules of the instructors and participants combined with their intellectual capabilities, the length and content were as they should be. I appreciate the opportunity to have participated in this first-rate workshop.

41. This was a well-prepared, relevant, and useful course. It will have a positive impact on the quality of information used for policy and management decisions regarding polar bears and other marine mammals by the U.S. government.

42. This was an amazing course and really broadened the capabilities of participants.

43. This was an excellent course. I have taken another workshop on Bayesian modeling and this course was notably more useful. I hope the PIs continue to teach a similar course. I have already recommended it to several colleagues.

44. This was an excellent training that "democratized" Bayesian modeling for ecologists and I greatly recommend it. It is extremely important for this "Bayesian Modeling for Ecologists" workshop to continue because like myself, I know many colleague scientists and faculty who are interested in using Bayesian approach, who had been reading about it, but who had been waiting for a course like this one to get them started.

45. This was an extremely important course for me, although I fear that since it was only one year ago (2015), this importance is not yet visible in teaching and research products. I anticipate that such products will emerge in the next year or two.

46. This was by far the absolute best statistics course I have ever taken. The instructors' approach to the subject matter really helped develop a strong foundational understanding of the material and the rationale for how and why certain steps are performed. This is in contrast to other courses where we jump right into the coding and running of models and the students are left without a clear understanding of why they did what they just did and how to take what they just did and apply it to their own situations.

47. This was one of the best courses I have ever taken. The teaching was clear, well-thought out, practical, non-patronizing or condescending…all abilities were welcomed and all questions encouraged. I learned so much and the atmosphere created by the instructors and fellow attendees was perfect. I now feel able to understand Bayesian analyses -- I just need to put my new knowledge into practice!

48. This was the best workshop I have ever taken, bar none. Fantastic work by the entire leadership team.

49. This workshop has been integral to my embracing and teaching the central tenets of the revolution in the application of statistics to hypothesis testing that is occurring in ecology and science in general -- i.e. the abandoning of reliance on NHST as the central paradigm, and the embracing of a more holistic approach to hypothesis generation and evaluation, of which Bayesian Modeling is one critical component -- at least this workshop and my reading and reflecting since then has convinced me that this is so. This revolution in my approach to data analysis is even more profound than the first one than changed my thinking 30 years ago (i.e. Stuart Hulbert's paper on pseudoreplication). Thus, the Bayesian Modeling Workshop not only was extremely valuable for what I learned about the details of applying Bayesian modeling, it was also instrumental in helping shape my philosophy of how science should be conducted. This workshop effectively meshed philosophy of science with the development of hands-on skills. It built a solid foundation for further development of expertise in Bayesian Modeling. This workshop is an excellent example of NSF funds very well spent - at least from my perspective as a senior-level ecologist.

50. This workshop was a transformative experience for my academic life. I really appreciate the opportunity to participate in such an excellent workshop, and I hope it could continue so that other young researchers can have the same opportunity.

51. Wonderful course! I have not had much opportunity to practice, which is why I would consider my expertise at reviewing papers and proposals that use Bayesian analyses to be rather low. But, I now feel comfortable tackling problems using a Bayesian approach and this will lead to better analyses in my future.