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Employment

July 2003 – Rensselaer Polytechnic Institute, Troy, NY
Professor of Mathematical Sciences
Professor of Decision Sciences and Engineering Systems
Professor of Information Technology

July 1998 – June 2003 Rensselaer Polytechnic Institute, Troy, NY
Associate Professor of Information Technology

July 1994 – June 2003 Rensselaer Polytechnic Institute, Troy, NY
Associate Professor of Mathematical Sciences
Associate Professor of Decision Sciences and Engineering Systems

August 1988 – July 1994 Rensselaer Polytechnic Institute, Troy, NY
Assistant Professor of Mathematical Sciences
Assistant Professor of Decision Sciences and Engineering Systems

January – June 2005 McMaster University, Hamilton, Ontario.
Visiting Professor

Aug 1997 – July 1998 Delft University of Technology, The Netherlands.
Visiting Professor

Education

Ph.D. Operations Research, Cornell University, Ithaca, N.Y. August 1988
Thesis: *Karmarkar's algorithm and combinatorial optimization problems*
Advisor: Michael J. Todd

M.S. Operations Research, Cornell University, Ithaca, N.Y. September 1986

B.A. Honours Mathematics, Cambridge University, England, June 1983

Courses Taught

Graduate courses:

<u>Date</u>	<u>Number</u>	<u>Title</u>	<u>Enrollment</u>	<u>Rating</u> (5pt scale)
1988 Fall	67.611	Mathematical Programming	8	4.4
1989 Spring	67.612	Combinatorial Optim and Integer Prog	18	4.1
1989 Fall	67.611	Mathematical Programming	12	4.2
1990 Fall	67.611	Mathematical Programming	10	4.4
1991 Spring	67.612	Combinatorial Optim and Integer Prog	15	4.7
1992 Spring	67.696	Advanced Linear & Nonlinear Programming	11	4.3
1992 Fall	67.611	Mathematical Programming	8	4.3
1993 Spring	67.612	Combinatorial Optim and Integer Prog	15	4.5
1993 Fall	67.611	Mathematical Programming	15	4.9
1994 Spring	67.696	Advanced Linear & Nonlinear Programming	7	5.0
1994 Fall	67.611	Mathematical Programming	8	4.9
1995 Spring	67.612	Combinatorial Optim and Integer Prog	20	4.8
1995 Fall	67.611	Mathematical Programming	8	4.9
1996 Spring	67.612	Advanced Linear & Nonlinear Programming	7	4.7

<u>Date</u>		<u>Number</u>	<u>Title</u>	<u>Enrollment</u>	<u>Rating</u> (5pt scale)
1997	Spring	67.612	Combinatorial Optim and Integer Prog	12	4.9
1999	Spring	MATP6620	Combinatorial Optim and Integer Prog	8	4.7
1999	Fall	MATP6600	Nonlinear Programming	8	5.0
2000	Spring	MATP6640	Linear Programming	10	4.9
2000	Fall	MATH6800	Computational Linear Algebra	25	4.8
2001	Spring	MATP6620	Combinatorial Optim and Integer Prog	16	4.8
2002	Spring	MATP6640	Linear Programming	13	4.9
2002	Fall	MATP6960	Stochastic Programming	12	4.8
2003	Spring	MATP6620	Combinatorial Optim and Integer Prog	12	4.9
2004	Spring	MATP6640	Linear Programming	18	4.3
2004	Fall	MATP6600	Nonlinear Programming	33	4.1
2005	Fall	MATP6620	Combinatorial Optim and Integer Prog	20	4.3
2006	Spring	MATP6640	Linear Programming	5	5.0
2007	Spring	MATP6620	Combinatorial Optim and Integer Prog	13	4.3
2007	Fall	MATP6600	Nonlinear Programming	9	

Junior/Senior level courses:

<u>Date</u>		<u>Number</u>	<u>Title</u>	<u>Enrollment</u>	<u>Rating</u> (5pt scale)
1990	Spring	67.412	Operations Research II	50	3.6
1991	Fall	65.411	Linear Algebra	40	3.1
1993	Spring	67.412	Operations Research II	35	4.5
1994	Spring	67.412	Operations Research II	24	4.6
1994	Fall	67.411	Operations Research I	50	4.6
1995	Spring	67.412	Operations Research II	35	4.8
1995	Fall	67.411	Operations Research I	40	4.5
1996	Spring	67.412	Operations Research II	35	4.5
1996	Fall	67.411	Operations Research I	50	4.4
1997	Spring	67.412	Operations Research II	35	4.8
1998	Fall	MATP4700	Math Models of Operations Research	35	4.7
2000	Fall	MATP4700	Math Models of Operations Research	22	4.3
2002	Fall	MATP4700	Math Models of Operations Research	22	4.6
2003	Fall	MATP4700	Math Models of Operations Research	35	4.7
2004	Fall	MATP4700	Math Models of Operations Research	26	4.5
2005	Fall	MATP4700	Math Models of Operations Research	19	4.4

Freshman/Sophomore level courses:

<u>Date</u>		<u>Number</u>	<u>Title</u>	<u>Enrollment</u>	<u>Rating</u> (5pt scale)
1990	Spring	65.130	Mathematics III	110	4.0
1990	Fall	65.130	Mathematics III	60	3.8
1991	Spring	65.130	Mathematics III	80	4.3
1991	Fall	65.130	Mathematics III	73	4.1
1992	Spring	65.130	Mathematics III	80	3.9
1992	Fall	65.130	Mathematics III	90	4.2
1996	Fall	65.120	Mathematics II	140	3.9
1999	Spring	MATH2010	Multivariable Calculus and Matrix Algebra	120	3.8
1999	Fall	MATH1020	Calculus II	100	3.4
1999	Fall	MATH1900	Art & Science of Mathematics I	30	
2000	Spring	MATH1901	Art & Science of Mathematics II	23	

<u>Date</u>	<u>Number</u>	<u>Title</u>	<u>Enrollment</u>	<u>Rating</u> (5pt scale)	
2002	Spring	MATH2010	Multivariable Calculus and Matrix Algebra	109	3.9
2003	Fall	MATH2010	Multivariable Calculus and Matrix Algebra	82	4.1
2005	Fall	MATH1900	Art & Science of Mathematics I	40	
2006	Spring	MATH1910	Art & Science of Mathematics II	40	
2007	Spring	MATH2800	Introduction to Discrete Structures	94	4.0
2007	Fall	MATH2800	Introduction to Discrete Structures	99	

Doctoral Theses Supervised:

Brian Borchers (Math), graduated August 1992, “Improved branch-and-bound algorithms for integer programming”. Won Joaquin B. Diaz prize (1992). First and current employer: New Mexico Tech (professor).

Zhao-Yang Cheng (Math), graduated August 1993, “A least squares approach to interior point methods with an application to geometric programming”. First employer: a financial company on Wall Street. Current employer: General Digital.

Srinivasan Ramaswamy (DSES), graduated December 1995, “Cutting plane algorithms for linear and convex programming”. First employer: United Airlines. Current employer: J.P. Morgan.

Bob Rush (DSES), graduated January 1998, “Decision-constrained stochastic programming for asset-liability management”. First employer: Lattice Financial. Current employer: Declaration Management and Research LLC.

Steve Braun (Math), graduated December 2001, “Solving a quadratic programming problem subject to orthogonality constraints”. First and current employer: Warren and Selbert.

Kartik Krishnan (Math), graduated August 2002, “Linear programming approaches to semidefinite programming problems”. First employer: Rice University (postdoc). Current employer: North Carolina State University (assistant professor).

Vasile (Luc) Basescu (Math), graduated August 2003, “An analytic center cutting plane method in conic programming”. First employer: St Joseph College. Current employer: Campbell and Company.

Xiaoyun Ji (Math), graduated December 2004, “Graph partition problems with minimum size constraints”. Won Joaquin B. Diaz prize (2004). First employer: RPI (postdoc). Current employer: BNSF.

Kris Farwell (Math), graduated May 2006, “Gomory cutting plane algorithm using exact arithmetic”. First and current employer: Siena College (assistant professor).

Earl (Rusty) Lee (DSES), graduated August 2006. Principal advisor was W. A. Wallace. I was Rusty’s co-advisor. “Assessing vulnerability and managing disruptions to interdependent infrastructure systems: A network flows approach”. First and current employer: University of Delaware (assistant professor).

Jinye Zhao (Math), graduated December 2007. Co-advised with Jong-Shi Pang. “Recent applications of Nash equilibria”. First and current employer: ISO – New England.

Chaoxiong Wang (Math), thesis defense November 2007, graduation May 2008. Co-advised with Jong-Shi Pang. “Power control for multiuser communication systems and computation of generalized Nash equilibria”.

Jing Hu (Math), graduation anticipated August 2008. Co-advised with Jong-Shi Pang.

Daryn Ramsden (Math), in progress.

Bin Yu (DSES), in progress.

Doctoral Committee Member at RPI

21 students in Mathematical Sciences, 22 students in DSES, 6 students in Computer Science, 2 students in Electrical and Systems Engineering, 2 students in Mechanical Engineering, and 1 student in Chemical Engineering.

Publications

Invited survey chapters (lightly refereed)

1. “Interior Point Algorithms for Integer Programming”, Chapter 6, pp. 223-248, in “Advances in Linear and Integer Programming”, edited by J. Beasley, Oxford University Press, 1996.
2. “Interior Point Methods for Combinatorial Optimization”, Chapter 11, pp. 417-466, in “Interior Point Methods in Mathematical Programming”, edited by T. Terlaky, Kluwer Academic Publishers, 1996.
3. “Interior Point Methods for Combinatorial Optimization”, with Panos Pardalos and Mauricio G. C. Resende. Pages 189-297 in the “Handbook of Combinatorial Optimization”, Volume 1, edited by D.-Z. Du and P. Pardalos, Kluwer Academic Publishers, 1998.
4. “Branch-and-Cut Algorithms for Integer Programming”, in the “Encyclopedia of Optimization”, edited by C. Floudas and P. Pardalos, June 2001.
5. “Cutting Plane Algorithms for Integer Programming”, in the “Encyclopedia of Optimization”, edited by C. Floudas and P. Pardalos, June 2001.
6. “Branch-and-bound methods for integer programming”, with Eva K. Lee, in the “Encyclopedia of Optimization”, edited by C. Floudas and P. Pardalos, June 2001.
7. “Branch-and-cut methods for combinatorial optimization problems”, pages 65-77 in the “Handbook of Applied Optimization”, edited by P. Pardalos and M. G. C. Resende, Oxford University Press, January 2002.
8. “Interior point methods for large scale linear programming”, with Kris Farwell and Daryn Ramsden, in the “Handbook of Optimization in Telecommunications”, Chapter 1, pages 3–25, edited by P. Pardalos and M. G. C. Resende, February 2006.

Contributions to edited compilations of original research (refereed to journal standards)

9. “On the Relationship Between the Search Directions in the Affine and Projective Variants of Karmarkar’s Linear Programming Algorithm,” (with M. J. Todd), Contributions to Operations Research and Econometrics: The Twentieth Anniversary of CORE, edited by Bernard Cornet and Henry Tulkens, MIT Press, Cambridge, pp. 237-250, 1990.
10. “Solving perfect matching problems using Karmarkar’s algorithm,” (with M. J. Todd), in Mathematical Developments Arising from Linear Programming; (J. Lagarias and M. J. Todd, editors), (Contemporary Mathematics, Volume 114), American Mathematical Society, pp. 309-318, 1991.
11. “Solving MAXSAT problems using branch-and-cut”, (with Steve Joy and Brian Borchers), Satisfiability Problem: Theory and Applications, AMS/DIMACS Series in Discrete Mathematics and Applications, Volume 35, pp. 519-536, 1997.
12. “Computational experience of an interior-point SQP algorithm in a parallel branch-and-bound framework”, (with E. K. Lee), Chapter 13, pages 329-347, “High Performance Optimization”, edited by H. L. Frenk et al., Kluwer Academic Publishers, 2000.
13. “Solving linear ordering problems with a combined interior point/simplex cutting plane algorithm”, (with Brian Borchers), Chapter 14, pages 349-366, “High Performance Optimization”, edited by H. L. Frenk et al., Kluwer Academic Publishers, 2000.
14. “A homogenized cutting plane method to solve the convex feasibility problem”, (with Erling Andersen, Kees Roos, and Tamas Terlaky). Chapter 10 in “Optimization Methods and Applications”, edited by X. Q. Yang et al, Kluwer Academic Publishers, April 2001.

15. "Semi-infinite linear programming approaches to semidefinite programming problems", (with Kartik Krishnan), Fields Institute Communications, volume 37, edited by P. Pardalos and H. Wolkowicz, pages 123–142, 2003.
16. "Managing Disruptions to Critical Infrastructure Interdependencies in the Context of the 2001 World Trade Center Attack", (with W.A. Wallace, D. Mendonça, E. Lee, and J. Chow), in "Beyond September 11: An account of post-disaster research", edited by M. F. Myers, Natural Hazards Research and Applications Information Center, University of Colorado, Program on Environment and Behavior, Special Publication #39, pages 165-198, 2003.
17. "Logic-based multi-objective optimization for restoration planning", with J. Gong, E. E. Lee, and W. A. Wallace, accepted for publication in Optimization and Logistics Challenges in the Enterprise, Springer, New York. W. Chaovalitwongse, K.C. Furman, and P.M. Pardalos (Eds). 2009.

Journal Articles

Published:

18. "A variant of Karmarkar's linear programming algorithm for problems with some unrestricted variables," (with M. J. Todd), SIAM Journal on Matrix Analysis and Applications, Vol. 10(1), pp. 30-38, 1989.
19. "Nonlinear Decision Variables in Work Design: Faculty Roles and Research Productivity," (with D. S. Rebne), Proceedings of the Decision Sciences Institute, San Diego, California, November 19-21, pp. 1426-1428, 1990.
20. "Solving combinatorial optimization problems using Karmarkar's algorithm," (with M. J. Todd), Mathematical Programming, Vol. 56(3), pp. 245-284, 1992.
21. "A primal-dual interior point cutting plane method for the linear ordering problem," (with B. Borchers), the COAL Bulletin, Vol. 21, pp. 13-18, November 1992.
22. "Updating lower bounds when using Karmarkar's projective algorithm for linear programming," Journal of Optimization Theory and Applications, Vol. 78, pp. 127-142, July 1993.
23. "The structure of assignment, precedence, and resource constraints in the ILP approach to the scheduling problem," (with S. Chaudhuri and R. A. Walker), Proceedings of the 1993 IEEE International Conference on Computer Design, pp. 25-29, 1993.
24. "An improved branch and bound algorithm for mixed integer nonlinear programming," (with B. Borchers), Computers and Operations Research, Vol. 21 (4), pp. 359-367, 1994.
25. "An interior point column generation method for linear programming using shifted barriers," SIAM Journal on Optimization, Vol. 4 (2), pp. 423-440, May 1994.
26. "Analyzing and Exploiting the Structure of the Constraints in the ILP Approach to the Scheduling Problem," (with S. Chaudhuri and R. A. Walker), IEEE Transactions on VLSI, Vol. 2 (4), pp. 456-471, December 1994.
27. "An Alternative Derivation of the Projective Interior Point Method for Linear Programming through the Least Squares Approach," (with Z.-Y. Cheng), Optimization, Vol. 31, pp. 95 - 106, 1994.
28. "The nonlinear effects of teaching and consulting on academic research productivity," (with D. S. Rebne), Socio-Economic Planning Sciences, Vol. 29, pp. 47-57, 1995.
29. "A Primal-Dual Interior Point Method for Linear Programming based on a Weighted Barrier Function," (with Z.-Y. Cheng), Journal of Optimization Theory and Applications, Vol. 87, pp. 301-321, 1995.

30. "Solving real-world linear ordering problems using a primal-dual interior point cutting plane method," (with B. Borchers), *Annals of OR*, Vol. 62, pp. 253-276, 1996.
31. "Fixing Variables and Generating Classical Cutting Planes when using an Interior Point Branch and Cut Method to solve Integer Programming Problems," *European Journal of Operational Research*, Vol. 97, pp. 139-148, 1997.
32. "A Computational Comparison of Branch and Bound and Outer Approximation Methods for 0-1 MINLPs," (with Brian Borchers), *Computers and Operations Research*, Vol. 24, pp. 699-701, 1997.
33. "Computational experience in nonlinear mixed integer programming", (with E. K. Lee), *Proceedings of Symposium on Operations Research*, August 1996, Braunschweig, Germany, (refereed), Springer-Verlag, pages 95-100, 1997.
34. "Computational experience of an interior point algorithm in a parallel branch-and-cut framework", (with E. K. Lee), *Proceedings of the Eighth SIAM Conference on Parallel Processing for Scientific Computing* (refereed), CD-ROM, 1997.
35. "An interior point cutting plane algorithm for Ising spin glass problems", *Proceedings of Symposium on Operations Research*, September 1997, Jena, Germany (refereed), Springer-Verlag, pages 114-119, 1998.
36. "Computational experience with an interior point cutting plane algorithm", *SIAM Journal of Optimization*, 10(4), pages 1212-1227, 2000.
37. "Stratified filtered sampling in stochastic optimization", (with John Mulvey, Bob Rush and Tom Willemain), *Journal of Applied Mathematics and Decision Sciences*, 4(1), pages 17-38, 2000.
38. "A long step cutting plane algorithm for linear and convex programming," (with S. Ramaswamy), *Annals of OR*, Vol 99, pages 95-122, 2000.
39. "An ellipsoid algorithm for equality-constrained nonlinear programs", (with Sharmila Shah and Mike Kupferschmid), *Computers and Operations Research*, Vol 28(1), pages 85-92, 2001.
40. "Restarting after branching in the SDP approach to MAX-CUT and similar combinatorial optimization problems", *Journal of Combinatorial Optimization*, Vol 5(2), pages 151-166, 2001.
41. "Realignment in the NFL", *Naval Research Logistics*, 50(7), pages 683-701, 2003.
42. "Polynomial interior point cutting plane algorithms", *Optimization Methods and Software*, 18(5), pages 507-534, 2003.
43. "Assessing Vulnerability of Proposed Designs for Interdependent Infrastructure Systems", (with E. Lee and W. A. Wallace), Published in the *Proceedings of the Hawai'i International Conference on System Sciences*, January 5-8, 2004, Big Island, Hawaii.
44. "Disruptions in Interdependent Infrastructure Systems", (with E. Lee and W. A. Wallace), *Proceedings of 2004 NSF Design, Service and Manufacturing Grantees and Research Conference Proceedings*, Dallas, Texas, January 2004. (CD-ROM)
45. "An approach for solving the integrative freight management simulation", (with Ellen Thorson and José Holguín-Veras), *Proceedings of the XIII Panamerican Conference on Traffic and Transportation Engineering*, Albany, NY, September 2004. (CD-ROM)
46. "Extreme Events and the Sustainability of Civil Infrastructure Systems", (with E. E. Lee and W. A. Wallace), *Proceedings of the International Workshop on Integrated Life-Cycle Management of Infrastructures*, The Hong Kong University of Science and Technology, Hong Kong SAR, PRC, December 2004.

47. “Decision technologies for protection of critical infrastructures”, (with Earl E. Lee, W. A. Wallace, and D. Mendonça). Proceedings of the 2005 Department of Homeland Security Science and Technology Directorate Conference - Working Together: R&D Partnerships in Homeland Security, Boston, MA, 2005.
48. “Using selective orthonormalization to update the analytic center after the addition of multiple cuts”, (with Sridhar Ramaswamy), *Journal of Optimization Theory and Applications*, 125(2), pages 431–451, 2005.
49. “A semidefinite programming heuristic for quadratic programming problems with orthogonality constraints”, (with Steve Braun). *Computational Optimization and Applications*, 31(1), pages 5–29, 2005.
50. “Finding optimal realignments in sports leagues using a branch-and-cut-and-price approach”, with Xiaoyun Ji. *International Journal of Operational Research*, 1(1–2), pages 101–122, 2005.
51. “A unifying framework for several cutting plane methods for semidefinite programming”, (with Kartik Krishnan). *Optimization Methods and Software*, 21(1), pages 57–74, February 2006.
52. “Semidefinite cut-and-price approaches for the maxcut problem”, (with Kartik Krishnan). *Computational Optimization and Applications*, 33(1), pages 51–71, 2006.
53. “Proximity Queries between Convex Objects: An Interior Point Approach for Implicit Surfaces”, with S. Akella, N. Chakraborty, and J. Peng. Proceedings of ICRA2006, the 2006 IEEE International Conference on Robotics and Automation.
54. “Branch-and-Price-and-Cut on the Clique Partition Problem with Minimum Clique Size Requirement”, with Xiaoyun Ji. *Discrete Optimization* 4(1), pages 87–102, 2007.
55. “Restoration of Services in Interdependent Infrastructure Systems: A Network Flows Approach”, with E. E. Lee and W. A. Wallace. *IEEE Transactions on Systems, Man, and Cybernetics–Part C: Applications and Reviews* 37(6), pages 1303–1317, 2007.
56. “Optimal placement of stereo sensors”, with M. Al Hasan and K. K. Ramachandran, *Optimization Letters* 2(1), pages 99–111, 2008.

Accepted:

57. “Solving MAX-SAT and weighted MAX-SAT problems using branch-and-cut”, (with Steve Joy and Brian Borchers), February 1998. Accepted for publication in the “*Journal of Combinatorial Optimization*” by a guest editor for a special issue. Has not yet appeared in print.
58. “A second-order cone cutting surface method: complexity and application”, with M. Oskoorouchi, May 2005, accepted for publication in *Computational Optimization and Applications*.
59. “Proximity queries between convex objects: an interior point approach for implicit surfaces”, with S. Akella, N. Chakraborty, and J. Peng, August 2006, accepted for publication in *IEEE Transactions on Robotics*.
60. “Selective Gram-Schmidt orthonormalization for conic cutting plane algorithms”, with V. L. Basescu, November 2006, accepted for publication in *Mathematical Methods of Operations Research*.
61. “On the global solution of linear programs with linear complementarity constraints”, J. Hu, J. E. Mitchell, J.-S. Pang, K. P. Bennett, and G. Kunapuli, February 2007, accepted for publication in the *SIAM Journal on Optimization*.

Submitted:

62. “Rebalancing an investment portfolio in the presence of convex transaction costs”, (with Steve Braun), December 2004.
63. “The clique partition problem with minimum clique size constraint”, with Xiaoyun Ji, May 2005.
64. “An analytic center cutting plane approach for conic programming”, with V. L. Basescu, June 2005.
65. “Multivehicle routing with profits and competition”, with E. Thorson and J. Holguín-Veras, October 2005.
66. “Properties of a cutting plane method for semidefinite programming”, (with Kartik Krishnan Sivaramakrishnan), September 2007.
67. “Modeling the Resilience of Interdependent Infrastructure Systems”, (with E. E. Lee and W. A. Wallace), December 2007.

Technical reports

68. “Using an Interior Point Method in a branch and bound algorithm for integer programming”, (with B. Borchers), 1991.
69. “Occupational Contingencies of Academic Work Design”, (with D. S. Rebne), 1993.
70. “On Updating the Analytic Center after the Addition of Multiple Cuts”, (with Sridhar Ramaswamy), 1994, revised 1998.
71. “A Long Step Cutting Plane Algorithm that uses the Volumetric Barrier”, (with Sridhar Ramaswamy), 1995.
72. “A tabu search procedure for target-matching in financial scenario generation”, (with Adam J. Berger, John Mulvey and Bob Rush), December 5, 1997.
73. “Semi-infinite linear programming approaches to semidefinite programming problem”, (with Kartik Krishnan), August 2001.
74. “Branch-and-cut for the k-way equipartition problem”, January 2001.
75. “Rebalancing an investment portfolio in the presence of transaction costs”, (with Steve Braun), November 2002.
76. “A Multi-Objective Programming Framework for Kernel Methods”, (with Jinbo Bi, Kristin P. Bennett and Minghu Song), in preparation for Operations Research, 2005

Book reviews

1. Book review: “Linear Programming. 1: Introduction”, by G. B. Dantzig and M. N. Thapa (Springer), reviewed for Optima, Number 57, pp. 13-14, 1998.
2. Book review: “Single facility location problems with barriers”, by Kathrin Klamroth (Springer), reviewed for SIAM Review, Volume 45(4), pages 834–836, 2003.
3. Book review: “Integrated Methods for Optimization”, by John N. Hooker (Springer). Review to appear in SIAM Review, 2008.

Research Grants and Contracts

1. “Using Interior Point Methods in a Cutting Plane Approach for Solving Integer Programming Problems,” June 1, 1990 - September 30, 1992; ONR; \$120,000.
2. “Graduate Traineeship,” May 15, 1993 - May 14, 1996, \$78,000, General Electric, for support of research and doctoral student, A. Hejna.
3. “Using Column Generation and Cutting Plane Methods to Solve Problems in Computational Logic,” February 1, 1994 - January 31, 1997, ONR, \$324,139.
4. “Graduate Traineeship”. December 15, 1994 - August 15, 1995. \$22,500, General Electric, for support of research and doctoral student, J. Bogart.
5. “Research Fellowship”, September 1, 1997 - August 15, 1998. \$20,000, NWO (Dutch Scientific Foundation), for sabbatical support.
6. “Mathematical Sciences Computing Research Environments”, co-Investigator with M. Holmes, K. Bennett, D. Isaacson, D. Schwendeman, and T. Yu, July 1998 – July 2001, NSF/DMS equipment grant, \$93,000.
7. “Semidefinite Programming and Interior Point Cutting Plane Algorithms”, September 1, 1999 – August 31, 2003, NSF/CCR, \$247,366.
8. “Disruptions in Interdependent Infrastructures”, co-Principal Investigator with W. A. Wallace, November 15, 2002 – November 15, 2003, NSF/DMII, exploratory, award number DMI 0228402, \$93,303.
9. “Decision Technologies for Managing Critical Infrastructure Interdependencies”, co-Principal Investigator with W. A. Wallace, August 15, 2003 – February 15, 2006, NSF/Civil Award number CMS 0301661, \$414,742.
10. “Polyhedral and non-polyhedral cutting plane methods: theory, algorithms, and applications”, September 1, 2003 – August 31, 2006, NSF/DMS Award number DMS 0317323, \$224,945.
11. “International Conference of Continuous Optimization: Rensselaer Polytechnic Institute, August 2-4, 2004”, co-PI with J.-S. Pang and K. P. Bennett. NSF/DMII Award number 0412377, \$30,000.
12. “Scientific Computing Research Environments for the Mathematical Sciences”, with D. Schwendeman, E. Giladi, and M. Holmes. NSF/DMS, September 2005 – September 2007, \$100,000.
13. “Cutting planes and surfaces, and conic programming”, September 1, 2007 – August 31, 2010, NSF/DMS Award Number DMS 0715446, \$259,999.
14. “Global Resolution of Convex Programs with Complementarity Constraints”, February 1, 2008 – November 30, 2010, The Optimization and Discrete Mathematics Program, AFOSR. Joint with Professor Jong-Shi Pang of the University of Illinois, Urbana-Champaign. RPI portion: \$249,962

Editorship of Journals, refereeing, and reviewing

1. Editorial Board Member, International Journal of Operational Research, 2004–
2. Guest co-editor, special issue of “Discrete Applied Mathematics”, based on the Seattle INFORMS Conference, October 1998.

3. Refereed papers for 4OR, American Mathematical Society (Conference Proceedings), Annals of OR, Computational Management Science, Computational Optimization and Applications, Computers and Industrial Engineering, Computers and Mathematics with Applications, Computers and Operations Research, Discrete Optimization, European Journal of Operational Research, Handbook of Interior Point Methods, IEEE Transactions on Systems, Man and Cybernetics, IEEE/ACM Transactions on Networking, Information Processing Letters, International Congress on Computational and Applied Mathematics, International Journal of Systems Science, International Transactions in Operations Research, Journal of Applied Numerical Mathematics, Journal of Computational and Applied Mathematics, Journal of Global Optimization, Journal of Machine Learning Research, Journal of Optimization Theory & Applications, Journal of Optimization Theory & Applications, Linear Algebra and Applications, Mathematical Programming, Mathematics of Operations Research, Operations Research, Optimization and Logistics Challenges in the Enterprise, Optimization Methods and Software, OR Letters, Proceedings of the MIC'99 Conference, Proceedings of Workshop on Large Scale Numerical Optimization, SIAM Journal on Optimization, SIAM Journal on Scientific Computing, SIAM Review, WEA
4. Several undergraduate and graduate texts reviewed for publishers.
5. Multiple proposals reviewed for NSF and other funding agencies. Served on several NSF panels.

Service to University

Colloquium Chairman: August 1991 - May 1992.

Advisor to Mathematical Sciences class of 1997, August 1993–May 1997.

Science Faculty Council, September, 1995 - August, 1997.

Chair, Math dept preliminary exam committee, Spring 2000 and Fall 2006.

Math dept Graduate Committee member, Fall 1999 - Summer 2004.

Advisor to Mathematical Sciences class of 2003, August 1999–May 2003.

Faculty Senate member, August 2000 – May 2002.

Chair of Computing Resources subcommittee of the Math Sciences Department Graduate Committee, February 2002 – Summer 2004.

Member, Mathematical Sciences department Prize Committee, 2004.

Chair, local organizing committee, International Conference on Continuous Optimization (ICCOPT-I), held at RPI, July 31-August 4, 2004.

Member, Middle States Accreditation Standard 14 Committee, 2004-2005.

Advisor to Mathematical Sciences class of 2009, August 2005–current.

Member, Mathematical Sciences department website review committee, 2005-06.

Member, Mathematical Sciences graduate committee, January 2007-.

Member, Department of Mathematical Sciences Head Search Committee, November 2007-.

Written letters of recommendation for approximately 50 undergraduate and 40 graduate students.

Professional Societies

INFORMS / Operations Research Society of America:

Member, 1984-1990.

Full Member, 1990-present

INFORMS Conference, Seattle, November 1998: Co-organized unified streams of approximately 70 talks on integer programming, combinatorial optimization, network optimization, and scheduling.

INFORMS Conference, Seattle, November 1998: Chaired two sessions.

INFORMS Conference, Atlanta, October 2003: Organized and chaired one session.

Mathematical Programming Society:

Member 1987 - present

Mathematical Programming Symposium, Lausanne, 1997: Co-organized stream of five mini symposia on column generation interior point methods.

Mathematical Programming Symposium, Lausanne, 1997: Chaired two sessions.

Mathematical Programming Symposium, Copenhagen, 2003: Co-organized stream of four minisymposia on nonsmooth optimization.

Mathematical Programming Symposium, Copenhagen, 2003: Chaired two sessions.

Chair, local organizing committee, inaugural Mathematical Programming Society International Conference on Continuous Optimization (ICCOPT-I), held at RPI, July 31 – August 4, 2004.

Mathematical Programming Symposium, Rio de Janeiro, 2006: Organized and chaired session.

SIAM:

Member 1987 - present

SIAM Conference on Optimization, Atlanta, May 1999: Chaired session.

INFORMS Conference, San Antonio, November 2000: Organized and chaired session.

SIAM representative on organizing committee for inaugural Mathematical Programming Society International Conference on Continuous Optimization (ICCOPT-I), held at RPI, July 31 – August 4, 2004.

Professional and Public Lectures

Invited Lectures

1. J. E. Mitchell and M. J. Todd, “A comparison between the affine and projective primal variants of Karmarkar’s algorithm,” SIAM Conference on Numerical Optimization, Houston, TX, May 1987.
2. J. E. Mitchell, “Solving Matching Problems Using Karmarkar’s Algorithm,” SIAM Conference on Discrete Mathematics, Atlanta, GA, June 1990.
3. J. E. Mitchell, “Using Interior Point Algorithms in Column Generation Methods,” University of Arizona, Tucson, AZ, November 1990.
4. J. E. Mitchell, “An Interior Point Column Generation Method for Linear Programming using Shifted Barriers,” ORSA/TIMS Conference, Los Angeles, CA, November, 1991.
5. J. E. Mitchell, “Interior Point Methods for Linear Programming.” Smith College, Northampton, MA, December 1991.
6. J. E. Mitchell, “Solving Integer Programming Problems using Interior Point Methods.” University of Waterloo, Waterloo, Ontario, Canada, November 1992.
7. J. E. Mitchell and S. Ramaswamy, “A Column Generation Method which uses the Central Trajectory,” Optimization Days (CORS, Montreal, Quebec, Canada, June 1994.
8. J. E. Mitchell, “Using an Interior Point Algorithm in a Cutting Plane Method for Solving Integer Programming Problems,” Faculty Research Seminar on Optimization in Theory and Practice, “University of Iowa, Iowa City, August 1994.
9. J. E. Mitchell, “Using an Interior Point Algorithm in a Cutting Plane Method for Solving Integer Programming Problems,” Mathematical Programming Conference, Ann Arbor, MI, August 1994.
10. B. Borchers and J. E. Mitchell, “A Comparison of Branch and Bound and Outer Approximation for 0-1 MINLPs,” IFORS Conference, St. Louis, MO, October 1995.
11. J. E. Mitchell, “Using an Interior Point Algorithm in a Cutting Plane Method for Solving Integer Programming Problems,” INFORMS Conference, New Orleans, LA, November 1995.

12. J. E. Mitchell, "Using an Interior Point Algorithm in a Cutting Plane Method for Solving Integer Programming Problems," SIAM Conference on Optimization, Victoria, BC, Canada, May 1996.
13. S. Ramaswamy and J. E. Mitchell, "Long Step Cutting Plane Algorithms for Linear Programming," INFORMS Conference, Atlanta, GA, November 1996.
14. J. E. Mitchell and E. K. Lee, "Solving Mixed Integer Nonlinear Programming Problems Using an Interior Point Method," INFORMS Conference, San Diego, CA, May 1997.
15. J. E. Mitchell and S. Ramaswamy, "A Long Step Cutting Plane Algorithm that Uses the Volumetric Center," Mathematical Programming Symposium, Lausanne, Switzerland, August 24 - 29, 1997.
16. J. E. Mitchell and B. Borchers, "Solving Integer Programming Problems with an Interior Point Cutting Plane Algorithm," Mathematical Programming Symposium, Lausanne, Switzerland, August 24 - 29, 1997.
17. J. E. Mitchell and B. Borchers, "Solving Integer Programming Problems with an Interior Point Cutting Plane Algorithm," ZIB Workshop on Computational Integer Programming, Berlin, November 17, 1997.
18. J. E. Mitchell, "Cutting plane and column generation methods using interior point methods," Erasmus University, Rotterdam, The Netherlands, November 6, 1997.
19. J. E. Mitchell, "Cutting plane and column generation methods using interior point methods – computational experience and theoretical results," (2 lectures), Technical University at Delft, Delft, The Netherlands, November 25, 1997.
20. J. E. Mitchell and S. Ramaswamy, "Adding many cuts with an interior point column generation method", APMOD 98, Larnaca, Cyprus, March 11, 1998.
21. J. E. Mitchell, "The computational performance of interior point cutting plane algorithms for integer programming problems", HPOPT 98, Rotterdam, The Netherlands, June 18, 1998.
22. J. E. Mitchell, "The computational performance of interior point cutting plane algorithms for integer programming problems", Interior Point Workshop, Trier, Germany, July 7, 1998.
23. J. E. Mitchell and B. Borchers, "Combining interior point and simplex cutting plane algorithms to solve linear ordering problems", EURO XVI, Brussels, Belgium, July 14, 1998.
24. J. E. Mitchell, "Solving large sparse MAXCUT problems using an interior point cutting plane algorithm", INFORMS Fall 1998, Seattle, October 1998.
25. J. E. Mitchell, E. Andersen, K. Roos, and T. Terlaky, "A homogeneous self-dual interior point cutting plane method", INFORMS Fall 1998, Seattle, October 1998.
26. J. E. Mitchell, S. Joy, and B. Borchers, "A comparison of methods for solving MAXSAT problems", INFORMS Fall 1998, Seattle, October 1998.
27. J. E. Mitchell, "Solving semidefinite programming problems using branch-and-bound", EURO XVII, Budapest, July 2000.
28. J. E. Mitchell and K. Krishnan, "A linear programming approach to semidefinite programming problems", Operations Research Group, Mathematics Center, IBM Yorktown Heights, April 9, 2001.
29. J. E. Mitchell and S. Braun, "Using Semidefinite Programming to Rebalance a Portfolio in the Presence of Transaction Costs", McGill University, March 2002.
30. V. L. Basescu and J. E. Mitchell, "Analytic center cutting plane method in conic programming", International Symposium on Mathematical Programming, Copenhagen, August 2003.

31. K. Krishnan and J. E. Mitchell, "Cutting plane methods for semidefinite programming", International Symposium on Mathematical Programming, Copenhagen, August 2003.
32. J. E. Mitchell and K. Krishnan, "Properties of a cutting plane method for semidefinite programming", International Symposium on Mathematical Programming, Copenhagen, August 2003.
33. V. L. Basescu and J. E. Mitchell, "An analytic center cutting plane method in conic programming", INFORMS Annual Meeting, Atlanta, October 2003.
34. J. E. Mitchell and K. Krishnan, "Properties of a cutting plane method for semidefinite programming", INFORMS Annual Meeting, Atlanta, October 2003.
35. K. Farwell and J. E. Mitchell, "Implementing Gomory's cutting plane algorithm in exact arithmetic", INFORMS Annual Meeting, Atlanta, October 2003.
36. X. Ji and J. E. Mitchell, "Clique partition problem with minimum clique size", INFORMS Annual Meeting, Atlanta, October 2003.
37. E. Lee, J. E. Mitchell, and W. A. Wallace, "Assessing Vulnerability of Proposed Designs for Interdependent Infrastructure Systems", HICSS-37, Hawaii, January 2004.
38. J. E. Mitchell, E. Lee, and W. A. Wallace, "Disruptions in Interdependent Infrastructure Systems", NSF Design, Service and Manufacturing Grantees and Research Conference Proceedings, Dallas, January 2004.
39. J. E. Mitchell and K. Krishnan, "A unifying framework for several cutting plane algorithms for semidefinite programming", Multiscale Optimization Methods and Applications, Gainesville, Florida, February 2004.
40. J. E. Mitchell and K. Krishnan, "A unifying framework for several cutting plane algorithms for semidefinite programming", Inaugural International Conference on Continuous Optimization, Troy, NY, August 2004.
41. J. E. Mitchell, "Cutting plane methods for conic programs", SIAM Conference on Optimization, Stockholm, Sweden, May 2005.
42. E. Lee, D. Mendonça, J. E. Mitchell, and W. A. Wallace, "Disruptions in Interdependent Infrastructures". Invited presentation given to senior management at Consolidated Edison's Manhattan Control Room, June 2006.
43. J. E. Mitchell and V. L. Basescu, "Conic cutting surface algorithms", International Symposium on Mathematical Programming ISMP2006, August 2006, Rio de Janeiro.
44. J. E. Mitchell and V. L. Basescu, "Selective Gram-Schmidt orthonormalization for conic cutting surface algorithms", Second International Conference on Continuous Optimization, Hamilton, Ontario, Canada, August 2007.
45. J. Hu, J.-S. Pang, and J. E. Mitchell, "On the Global Solution of Linear Programs with Linear Complementarity Constraints", Second International Conference on Continuous Optimization, Hamilton, Ontario, Canada, August 2007.
46. J.-S. Pang, J. Hu, and J. E. Mitchell, "On the Global Solution of Linear Programs with Linear Complementarity Constraints", International School of Mathematics 'Guido Stampacchia' 46th Workshop: New Problems and Innovative Methods in Nonlinear Programming, Erice, Italy, August 2007.
47. J. E. Mitchell, J. Hu, and J.-S. Pang, "On the Global Solution of Linear Programs with Linear Complementarity Constraints", INFORMS Annual Meeting 2007, Seattle, WA, November 2007.

48. J. Gong, E. E. Lee, J. E. Mitchell, and W. A. Wallace, "Logic-based Multi-objective Optimization for Restoration Planning", INFORMS Annual Meeting 2007, Seattle, WA, November 2007.
49. E. E. Lee, J. E. Mitchell, and W. A. Wallace, "Decision Support for Assessing Vulnerability Among Interdependent Critical Infrastructure Systems", INFORMS Annual Meeting 2007, Seattle, WA, November 2007.
50. M. Oskoorouchi and J. E. Mitchell, "A Second-order Cone Cutting Surface Method: Complexity and Application", INFORMS Annual Meeting 2007, Seattle, WA, November 2007.

Contributed Lectures

51. J. E. Mitchell and M. J. Todd, "Computational experiments on matching problems using Karmarkar's algorithm," Workshop on Computational Discrete Optimization, (sponsored by the Mathematical Sciences Institute), Cornell University, Ithaca, N.Y., June 1987.
52. J. E. Mitchell and M. J. Todd, "Computational experiments on perfect matching problems using Karmarkar's algorithm," ORSA/TIMS Conference, St. Louis, MO, October 1987.
53. J. E. Mitchell and M. J. Todd, "Solving linear ordering problems using Karmarkar's algorithm," TIMS/ORSA Conference, Washington, D.C., April 1988.
54. J. E. Mitchell and M. J. Todd, "Karmarkar's algorithm and combinatorial optimization problems," Mathematical Programming Conference, Tokyo, August 1988.
55. D. S. Rebne and J. E. Mitchell, "Nonlinear Decision Variables in Work Design: Faculty Roles and Research Productivity," Decision Sciences Institute Conference, San Diego, CA, November 1990.
56. B. Borchers and J. E. Mitchell, "Using an Interior Point Method in a Branch and Bound algorithm for Integer Programming," Mathematical Programming Conference, Amsterdam, August 1991.
57. B. Borchers and J. E. Mitchell, "Using an Interior Point Method in a Branch and Bound Algorithm for Integer Programming," ORSA/TIMS Conference, Los Angeles, CA, November 1991.
58. J. E. Mitchell and B. Borchers, "A Primal-Dual Interior Point Method with Cutting Planes for the Linear Ordering Problem," SIAM Conference on Optimization, Chicago, IL, May 1992.
59. J. E. Mitchell and S. Ramaswamy, "A Path-Following Cutting Plane Algorithm for Linear and Integer Programming," ORSA/TIMS Conference, Phoenix, AZ, November 1993.
60. B. Borchers and J. E. Mitchell, "An Improved Branch-and-Bound Algorithm for MINLPs," ORSA/TIMS Conference, Phoenix, AZ, November 1993.
61. B. Borchers, S. Joy and J. E. Mitchell, "Solving MAXSAT with Heuristics and Branch and Cut," 1st International Joint Workshop on Artificial Intelligence and Operations Research, Timberline, OR, June 1995.
62. J. E. Mitchell, S. Joy and B. Borchers, "Solving weighted MAXSAT Problems Using Branch and Cut," DIMACS Workshop on Satisfiability, Rutgers University, NJ, March 1996.
63. J. E. Mitchell, "Using an Interior Point Algorithm in a Cutting Plane Method for Solving Integer Programming Problems," Fields Institute Workshop on Interior Point Methods for Combinatorial Optimization, Toronto, Canada, May 1996.
64. J. E. Mitchell, S. Joy and B. Borchers, "Solving Weighted MAXSAT Problems Using Branch and Cut," SIAM Conference on Optimization, Victoria, BC, Canada, May 1996.

65. E. K. Lee and J. E. Mitchell, "Computational Experience in Nonlinear Mixed Integer Programming," Symposium on Operations Research, TU Braunschweig, Germany, September 1996.
66. B. Borchers, J. E. Mitchell and S. Joy, "Three Approaches to the Exact Solution of MAXSAT Problems," INFORMS Conference, Atlanta, GA, November 1996.
67. J. E. Mitchell and B. Borchers, "Solving Linear Ordering Problems with a Combined Interior Point/Simplex Cutting Plane Algorithm," Workshop on High Performance Optimization Techniques, Erasmus University, Rotterdam, August 20 - 22, 1997.
68. J. E. Mitchell and E. K. Lee, "Solving Mixed Integer Nonlinear Programming Problems Using an Interior Point Method," Workshop on High Performance Optimization Techniques, Erasmus University, Rotterdam, August 20 - 22, 1997.
69. J. E. Mitchell, "An Interior Point Cutting Plane Algorithm for Ising Spin Glass Problems," Friedrich-Schiller-Universitat, Jena, Germany, September 3 - 5, 1997.
70. J. E. Mitchell, "Solving large sparse MAXCUT problems using an interior point cutting plane method", Combinatorial Optimization 98, Brussels, Belgium, April 15-17, 1998.
71. J. E. Mitchell, "Computational experience with interior point column generation and cutting plane methods", SIAM Conference on Optimization, Atlanta, May 1999.
72. J. E. Mitchell, "Branch-and-cut for the k-way equipartition problem", CO2000: Combinatorial Optimisation Symposium, Greenwich, London, England, July 2000.
73. J. E. Mitchell, "Solving semidefinite programming problems using branch-and-bound", Workshop on Interior Point Methods, Budapest, July 2000.
74. J. E. Mitchell, "Branch-and-cut for the k-way equipartition problem", International Symposium on Mathematical Programming 2000, Atlanta, August 2000.
75. J. E. Mitchell, "Realignment in the NFL", INFORMS 2000, San Antonio, November 2000.
76. K. Krishnan and J. E. Mitchell, "Solving a semidefinite program (SDP) as an LP", Novel Approaches to Hard Discrete Optimization Conference at the University of Waterloo, Waterloo, Canada, 28th April 2001.
77. K. Krishnan and J. E. Mitchell, "Linear Programming (LP) approaches to semidefinite programming (SDP) problems", 1st Annual McMaster Optimization Conference : Theory and Applications (MOPTA 01), at McMaster University, Hamilton, Canada, 4th August 2001.
78. J. E. Mitchell and S. Braun, "Using Semidefinite Programming to Rebalance a Portfolio in the Presence of Transaction Costs", SIAM Conference on Optimization, Toronto, Ontario, Canada, May 2002.
79. J. E. Mitchell and K. Krishnan, "A cutting plane SDP method for MaxCut problems", 2nd Annual McMaster Optimization Conference : Theory and Applications (MOPTA 02), at McMaster University, Hamilton, Canada, August 2002.
80. J. E. Mitchell and K. Krishnan, "Properties of a cutting plane method for semidefinite programming", 3rd Annual McMaster Optimization Conference: Theory and Applications (MOPTA 03), at McMaster University, Hamilton, Canada, August 2003.
81. E. E. Lee, W. A. Wallace, and J. E. Mitchell, "Decision Technologies for Protection of Critical Infrastructures", Department of Homeland Security Science and Technology Directorate Conference - Working Together: R&D Partnerships in Homeland Security, Boston, MA, May 2005.

82. X. Ji and J. E. Mitchell, "Minimum weight constrained forest problems", Optimization Days, Montreal, Canada, May 2005.
83. M. Oskoorouchi and J. E. Mitchell, "A Cutting Surface Method That Uses Linear and Second-Order Cone Cuts", SIAM Conference on Optimization, Stockholm, Sweden, May 2005.
84. E. E. Lee, W. A. Wallace, and J. E. Mitchell, "Decision Technologies for Protection of Critical Infrastructures", Natural Hazards Workshop, Boulder, CO, July, 2005.
85. X. Ji and J. E. Mitchell, "Minimum Weight Constrained Forest Problem", Optimization Days, Montreal, May 2005.
86. X. Ji and J. E. Mitchell, "Branch-and-price-and-cut on clique partition problems with minimum size requirement", IMA Special Workshop: Mixed-Integer Programming, at the University of Minnesota, July 25 - 29, 2005.
87. M. Oskoorouchi and J. E. Mitchell, "ACCPM with Multiple Second-order Cone Cuts", INFORMS Annual Meeting, San Francisco, CA, November 2005.
88. E. E. Lee, W. A. Wallace, and J. E. Mitchell, "The Interdependent Layered Network Model for Protection of Critical Infrastructures", Institute for Operations Research and the Management Sciences Annual Meeting, San Francisco, CA, November, 2005.
89. J. Gong, E. E. Lee, J. E. Mitchell, and W. A. Wallace, "Logic-based optimization for interdependent layered networks (ILN) problems", DIMACS Workshop on Computational Optimization and Logistics Challenges in the Enterprise (COLCE), ExxonMobil Research & Engineering, Annandale, NJ, April 2006.
90. J. Gong, E. E. Lee, J. E. Mitchell, and W. A. Wallace, "Logic-based optimization for interdependent layered networks (ILN) problems", INFORMS Annual Meeting, Pittsburgh, PA, November 2006.
91. M. Oskoorouchi and J. E. Mitchell, "An Analytic Center Cutting Surface Method: Complexity and Application", INFORMS Annual Meeting, Pittsburgh, PA, November 2006.

Honors and Awards

Obermann Fellowship, University of Iowa Center for Advanced Studies, August 1994.
 Mathematical Sciences Institute Fellowship, 1986-1987
 Cornell Graduate Fellowship, 1983-1986
 Exhibition, Cambridge University, 1982-1983

Other Activities

1. Developed a bibliography of optimization references that is available online, and which is cited in lists of available bibliographies: <http://www.rpi.edu/~mitchj/optim.bib>. (For an example of a citation, see "The Collection of Computer Science Bibliographies", <http://liinwww.ira.uka.de/bibliography/Math/optim.html>.)
2. Developed a list of operations research web sites that is widely referenced: http://www.rpi.edu/~mitchj/sites_or.html
3. Datasets and generators for various problems made available online: <http://www.rpi.edu/~mitchj/generators>
4. Consulted for Trizetto for 6 days in 2004.
5. Consulted for BNSF Railway for 5 days in 2007.