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SYMPOSIA ON SYSTEMS ANALYSIS IN FOREST RESOURCES: A 50TH YEAR ANNIVERSARY (1975-2024)

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Abstract.On the 50th anniversary of SSAFR, we present a brief survey and summary of the previous meetings and how the methods and applications presented have changed. References to previous surveys of SSAFR papers are included. From the 1st symposium in 1975 through the 20th in 2024, a consistent theme has been participation from a wide range of scientists from university, agency, corporate and non-governmental organizations from around the world. Some of the applications covered include fire management, transportation, multicriteria optimization, forest and land management planning, ecological/environmental analysis, biodiversity and sustainability, decision support systems, stochastic methods and hierarchical planning. While some topics from earlier years have lost currency, new topics have gained in popularity. Climate change has not been emphasized often as a specific topic, but it has been addressed in many areas such as fire management, biodiversity and sustainability, ecological/environmental considerations and stochastic methods. As we look to the future, we are confident that systems analysts will continue to provide solutions and insights into the pressing problems and issues addressed by future generations.

Keywords: SSAFR; history; OR methods and applications; planning; management.

1 Introduction

Beginning with the 1^{st} SSAFR in 1975 at the University of Georgia, Athens, GA and including this 20^{th} SSAFR in 2024 in Hondarribia, Basque Country, Spain, a large and talented pool of academics, government researchers, private industry and non-governmental scientists have gathered every few years to share the results of their analytical investigations and findings. Over this fifty-year period, there has been a tremendous explosion in innovative technologies which have had a significant impact on the development and use of systems analysis tools.

In 1975, personal computers, the internet, cell phones, laptops, tablets, cloud computing/data storage, easy to use apps (i.e., word processors, spreadsheets, power points, etc.), LIDAR, AI on handheld devices, parallel computing and extensive software for optimization and simulation – to name a few, did not exist, or if they did were in their infancy. It is difficult to imagine how the field of operations research and applications to natural resources issues would look today without these innovative technologies. Clearly, the disciplines of computer science and operations research are intertwined.

As documented elsewhere by Martell (2007a), Bare and Weintraub (2015), Ronnqvist et al. (2023) and others, an early use of operations research in the forest industry occurred in the mid-1950's to address the paper trim and lumber grade recovery problems. Similarly, linear programming was used to analyze harvest schedules, site rehabilitation analysis and plywood production and distribution problems. Since the 1960s, operations research applications to various forestry and other natural resource problems have exploded. In this paper we summarize these developments to provide a historical perspective.

2 Origins of SSAFR

At the 1970 Society of American Foresters Annual Convention in Las Vegas, a small group met informally to discuss how to form a new working group concentrating on the use of systems analysis to solve forestry problems. Among those present were leading academics, government and industry representatives interested in promoting the use of systems analysis in forestry. Formed two years later in 1972, the Systems Analysis Working Group, Society of American Foresters was the prime organizer of the early symposia, with the senior author of this paper serving as the first chair of the working group.

In the 1980s, a forestry cluster within INFORMS was formed and the two groups organized subsequent symposia. And, in the early 1990s, the International Federation of Operational Research Societies sponsored additional symposia. Since then, other organizations such as the Association of European Operational Research Societies and the International Union of Forest Research Organizations (IUFRO) have organized symposia around the world where systems analysis papers were presented.

3 SSAFR Over the Past 50 Years

Tables 1 and 2 (Appendix A) contains a summary of the SSAFR conducted to date. Included are the dates, locations, sponsoring organizations, people responsible for organizing the symposia, the number of papers presented and a summary of the applications and modeling techniques addressed at each symposium. Below, we summarize the historical trends that are evident from the data in Tables 1 and 2 as the applications and techniques have changed over the past 50 years.

As expected, presentations at the first few SSAFR concentrated on issues related to forest production. Multiple use and forest planning, fire management, timber harvesting and transportation, national forest planning using linear programming, multicriteria planning models, stand-level optimization, risk analysis and regional analysis dominated the first three symposia held between 1975-1988.

During the 1970s and 80s, several survey articles concerning forestry operations research models were published. A few were those of Schopfer and Hofle (1970), Bare (1971), Row and Schmelling (1971), Martin and Sendak (1973), Martell (1982), Bare et al. (1984), Harrison and de Kluyver (1984), Kallio et al. (1986) and Romero and Rehman (1987).

While forest planning, transportation, risk assessment, fire and fuel management and timber harvest scheduling remained as important areas of study, many of the symposia held during the 1990s contained new applications of operations research dealing with ecological modeling and ecosystem management, spatial forest planning including adjacency constraints, timber and price modeling, growth and yield models, manufacturing and log production, forest valuation, industry profitability, climate impacts and environmental concerns.

Survey articles published during the 1990s include those of Schuster et al. (1993), Hof (1993), Weintraub and Bare (1996), Mowrer (1997), Hof and Bevers (1998), Martell et al. (1998) and Helles et al. (1999).

Symposia in the 21^{st} Century continued to report on new developments across the above-described applications as well as dealing with additional topics such as biodiversity, carbon and biomass modeling, AI, eco-services, sustainability, value chain optimization, remote sensing and knowledge management. This illustrates that forest researchers and analysts have turned their modeling efforts towards contemporary forest management issues of importance to the forestry profession and society at large.

During the first decade of the 21^{st} century, survey articles were published by Midgley and Reynolds (2001), de Steiguer et al. (2003), Bettinger and Chung (2004), Gordon et al. (2004), Mendoza and Martins (2006), Weintraub and Romero (2006), Martell (2007a), Martell (2007b), Weintraub et al. (2007), Diaz-Balteiro and Romero (2008), D'Amours et al. (2008), Ananda and Herath (2009) and Martell (2009).

Additionally, many applications of operations research to natural resource problems expanded from the use of single objective models to include multiple objectives. The need for these models arises from both single and multiple decision maker situations. Stakeholder groups can hold competing values regarding managing public forests and private landowners can have multiple conflicting forest management objectives. Diaz-Balteiro and Romero (2008) demonstrated the need to use multicriteria decision methods (MCDM) in natural resource management to better reflect society's perception that forests are increasingly used for multiple purposes and user groups. The authors reviewed the use of MCDM in forestry over a 30-year period from the mid-1970s to the mid-2000s. Their survey of 255 MCDM studies revealed that over 60% were published in the 21st century and 25% in the 1990s. Over the past 30 years, 30.5% of the studies were related to harvest and extended harvest scheduling (models that include resources beyond timber);

13.3% to forest biodiversity; 11.8% to regional planning; 9% to forest industry; 8.6% to risk and uncertainty; 6.7% to sustainability; 4.3% to forestation; and 15.7% to miscellaneous topics. Technique wise, they found that multiple objective programming was used in 9.3% of the studies; goal programming 14.9%; compromise programming 3.3%; multiattribute utility theory 14.2%; fuzzy multicriteria programming 4%; analytic hierarchy process (AHP) 18.5%; other discrete methods 9.6%; data envelope analysis 10.9%; and group decision making techniques 15.3%. Their analysis also revealed that over 30 years, reported studies involving forest industry and sustainability increased in number; harvest and extended harvest scheduling declined, although the latter contributes the largest percentage of studies; while forest biodiversity, risk and uncertainty and regional planning remained at relatively constant percentages of the studies. Among reported MCDM methodologies, goal and multiple objective programming decreased dramatically over time while group decision making, data envelope analysis and other discrete methods increased.

After the mid-2000s, multiple objective programming received increased attention - this time in the context of spatial forest and conservation planning. This was likely due to rapidly accelerating hardware and optimization software technologies that allowed the otherwise computationally expensive discrete multiple objective programming methods to be solved on personal computers in practical times. Tóth et al. (2006) and Tóth and McDill (2009) provided an overview of these methods, documented in the literature, that could be used for spatial forest planning and compared their computational performance (solution times to optimality) with those of the new models that the authors proposed. A common feature of these methods was their capability to generate entire sets of management alternatives that were Pareto-optimal regarding the objectives included. Pareto-optimality in this context meant that only those management plans were identified if projected achievements on any given objective function could not be further improved without compromising achievements on another function. These types of Pareto-generating methods have received significant attention in systems analysis for forest resources because in most cases involving forest planning, public forests in particular, it was not possible to determine upfront (pre-optimization) as to what relative weights to assign to the competing objectives. Pareto-generating methods, however, do not require such a priori prescription of weights. Decision makers can make more informed decisions if all compromise management alternatives are identified regardless of what relative objective preferences (weights) these alternatives represent. A review paper by Ananda and Herath (2009) provides additional evidence of the usefulness of MCDM in forest planning.

Other survey papers published during the second and third decades of the 21st century include Yousefpour et al. (2011), Minas et al. (2012), Pasalodos-Tato et al. (2013), Borges et al. (2014), Bare and Weintraub (2015), Pacheo et al. (2015), Ronnqvist et al. (2015), Martell (2015), Acosta and Corral (2017), Diaz-Balteiro et al. (2017), Woolford et al. (2017), Acuna et al. (2019), Thompson et al. (2019), Tóth (2020), Blanco and Lo (2023), Ronnqvist et al. (2023) and Krsnik et al. (2024).

Diaz-Balteiro et al. (2017) surveyed the MCDM literature with respect to articles referencing sustainability. They found 271 papers published between 1999-2015 and, of these, 57 referenced economic activities related to agriculture, forestry and fishing. About 10 of the latter group related directly to forestry. Sustainability was evaluated by using common metrics for criteria (an average of 4.2 per application) and indicators (an average of 19 per application). Over all 271 studies, those using continuous distance measures like goal or compromise programming were far outnumbered by studies using discrete methods such as the analytic hierarchy process or the average weighted mean – the two most popular methods overall. It was also observed that the analytic hierarchy process, group decision making methods and fuzzy multicriteria programming increased in use over time while the average weighted mean method decreased. Further, many studies adopted an approach where an MCDM method was used within a group decision-making context.

Krsnik et al. (2024) describe a multicriteria DSS that uses the analytic hierarchy process to access physical and social-economic tradeoffs over temporal and spatial dimensions to help resolve appropriate forest uses such as commodity production, conservation and eco-services. In addition to discussing the role of various MCDM techniques, the paper also addresses risk and uncertainty issues and provides a list of references which illustrate various ways researchers have applied MCDM techniques when addressing complex forest planning issues.

The increased use of MCDM methods is consistent with society's changing views of forests which reflect a growing number of forest values beyond commodity production. Thus, reliance on multicriteria methods to help resolve conflicts between private and public sector resource managers, user groups and society at large can be expected to continue to increase in importance.

Incorporating uncertainty and risk into operations research natural resource models has been a daunting challenge for decades. However, in working with the long-time frames and the implied uncertainty associated with the management of natural resources, the need for an increased use of these methods is obvious. While wildland fire management issues provide the most visible example where uncertainty issues abound, natural resource planning and management, in general, are also affected by similar economic, ecological and sociological (e.g., regulatory) uncertainties. In addition to physical uncertainties associated with fire, insect and wind events are economic uncertainties such as prices and interest rates. Lastly, there are uncertainties associated with political and social factors making it very difficult to uncover the preferences of interest groups, landowners and various publics when describing future courses of action.

As concluded by Bare and Weintraub (2015)," ... advances in algorithmic efficiency, increased computational capabilities and comprehensive and easily updated information systems have allowed researchers and analysts to develop ever more complex and realistic models." Yet, challenges to continue these advances will confront researchers of the future.

4 What Does the Future Portend?

As we look to future uses of operations research in natural resources management, it is appropriate to reflect on some of the challenges that operations research analysts will likely face. In making these reflections we recognize that predicting the future is a very risky endeavor. Yet, thinking about future possibilities allows us to be better prepared for what may unfold. Some of these challenges were described by Weintraub and Bare (1996) and Martell et al. (1998), while others are more recent as described by Yousefpour et al. (2011), Borges et al. (2014), Johnson et al. (2018) and others discussed below.

Ronnqvist et al. (2015) define 33 open problems providing challenges to the OR community. These are organized around the following topics with the number of challenges in parenthesis: operational harvesting (5), transportation and routing (4), tactical planning (2), spatial and environmental concerns (2), strategic forest management (3), wildlife conservation (3), fire management (3), value chain management (3), stochastic programming (2), robust optimization (2), hierarchical planning (2), and multiple criteria in forest resource planning (2). While this list is extensive and well described, the following discussion brings additional issues into focus.

We must recognize that operations research models require large amounts of data that are costly to acquire, analyze and maintain and that models that use these data are costly to develop, test and use. Consequently, it is usually large landowners who engage in these endeavors. An open question is how useful these models are for small private landowners, community forests, public interest groups and NGOs involved in natural resource issues. All user groups remain dependent on current information and technology, but modelers and users do not always speak the same language. This implies that to be more effective, systems analysts must find ways to work directly with diverse public community groups, decision makers and a variety of public and private landowners.

As described by Johnson et al. (2018), models oftentimes do not give proper weight to factors inherent in many decision-making situations that are hard to observe, quantify or predict such as environmental impacts of management, enhancement of biodiversity, scenic beauty, wildlife habitat quality and other activities that involve non-market values. Finding ways to incorporate expert judgment and experience will build the trust of non-modelers and better represent the decision environment faced by many natural resource professionals.

Thompson et al. (2019) discuss this topic with reference to wildfire management and state that: "*To fully capitalize on the potential of analytics, organizations may need to catalyze cultural shifts that cultivate stronger appreciation for data-driven decision processes and develop informed skeptics that effectively balance both judgment and analysis in decision-making.*" In describing the application of operations research to fire management issues, Thompson and Calkin (2011) and Martell (2015) echo this sentiment with the latter concluding that, even though "*we expect fire managers to practice 'science-based management', we do not provide them with enough of the science and technology they need to achieve what society expects of them.*" As a consequence, fire managers likely will be unable to adequately address the impact of the social, economic and ecological consequences of their decisions.

Blanco and Lo (2023) emphasize that a more "*participatory process in which model users and forest stakeholders interact with forest modelers during the inception of the modeling studies is being increas-*

ingly recognized as fundamental for the model to make an actual impact in the forest sector." In their review of MCDM methods, Mendoza and Martins (2006) state that *"... knowledge about forest ecosystems is seldom complete, known with certainty or fully understood. Hence, the capability to accommodate these gaps in information and knowledge through qualitative data, expert opinions, or experiential knowledge is a distinct advantage. Further, it is conveniently structured to enable a collaborative planning and decision-making environment.*"

Acosta and Corral (2017) assess the importance of stakeholder participation in defining and assessing alternatives when selecting the most appropriate MCDM technique to use and report that *"... the one that best fits the purpose is the one that not only allows social actors to contribute information and to express their preferences, but also enables them to deliberate the results obtained.*" Midgley and Reynolds (2001) in addressing this issue conclude, *"... in the increasingly complex, interdisciplinary and politicized world of environmental planning, if we want to enhance expert support using OR, it will be vital to do more than just deal with the technical difficulties associated with modeling the natural world. This is not to say that the technical issues are trivial or unimportant (far from it), but it will also be necessary to address the messier social worlds of values and ethics in which both OR support and environmental issues are embedded. A major challenge for OR practitioners will be to develop methodologies and methods that can deal with all three of the generic themes identified in this research: complexity and uncertainty, multiple values and political effects.*"

As mentioned earlier, adequately incorporating risk and uncertainty and/or multiple criteria into our decision models remains challenging even though resource managers routinely make decisions involving these factors. While much work has been published regarding both topics, additional developments are needed to transfer this information to decision makers in an easily understood format. Examples of progress include the work of Thompson and Calkin (2011), Pasalodos-Tato et al. (2013), Pacheo et al. (2015) and Thompson et al. (2019). Yousefpour et al. (2011) surveyed approaches for treating risk and uncertainty using adaptive management under climate change. After surveying the literature, they concluded that two challenges remain. The first is "*the modeling of uncertainty related to climate change*" and the second is the "*need for simple but valid forest growth models*" which are responsive to changing climate, provide outputs that can be linked to forest and landscape models and that can be easily used to evaluate decision alternatives.

Suggestions to incorporate the work of social scientists who have examined ways that preferences are expressed in the presence of uncertainty and multiple values are reshaping how models are being constructed and used. Hopefully, collaboration among OR experts, social and natural scientists, public interest and community groups, policy makers and decision makers will lead to more informed decisions and the subsequent management of our natural resources.

Lastly, we invite the readers to consider an open decision problem of great practical importance in systems analysis in forest resources that requires the mathematical integration of several of the OR challenges we listed above. In its broadest form, the problem can be stated as follows:

How accurately does one have to know the current state of a system, and how accurately does one have to be able to predict future states of that system to make optimal management decisions?

The "system" mentioned here can be a coupled natural-human system, such as a managed forest, that includes trees, plants and wildlife of various species, as well as stakeholders and decision makers. The current state of the system can be described in terms of an inventory of its components including trees, plants, etc., along with their various attributes of interest such as merchantable volume, height or population size. Such an inventory can be acquired or estimated with the use of various statistical sampling methods. Future states of a forest can be predicted under different management scenarios with the use of growth-and-yield simulators. Because inventory sampling and growth-and-yield projections are not without costs, it is natural to ask just how many resources should one invest in gaining more accurate information about the current state of the forest as well as its predicted future states under different management scenarios? In principle, the answer to this question is relatively simple once the objectives of management are clearly defined. If the benefits of more accurate knowledge, as measured by the achievement of management objectives projected to result from the optimal decisions, which in turn were derived from that knowledge, minus the costs of acquiring that knowledge are positive, it is reasonable to make the investment. Then, the optimal amount of investment in knowledge can be found when that net benefit diminishes to zero.

Although the above proposed benefit-cost analysis (a.k.a., marginal analysis) is straightforward in principle, its practical implementation in the context of forest systems decision making is far from trivial. One of the difficulties is that while the costs of sampling (i.e., acquiring new data) are typically expressed in monetary instruments (e.g., in US dollars), achievements of management objectives might or might not be measured the same way. Timber revenues in US dollars can be directly compared to costs, but projected improvements in (say) wildlife habitat or aesthetics are much harder to quantify in monetary terms.

An even more serious difficulty arises from the fact that future benefits or objective achievements that result from various management decisions must be *predicted* today with a great deal of uncertainty about the future. This contrasts sharply with the costs of sampling, data processing and simulations, which are typically incurred in the present, and can be assessed with more certainty. While this mismatch of uncertainty in quantifying benefits vs costs can be mediated with the use of appropriate discount rates, the task of how exactly to adjust these rates for uncertainty remains very challenging. This problem is known as the expected value of information problem, and we believe this to be one of the biggest practical challenges for OR analysts to tackle in the context of forest or natural resources planning.

In summary, to retain the trust of users of operations research models, the challenges we face are to improve: a) communication channels between modelers, a variety of interest groups and decision makers in all phases of project planning and management, b) the use of non-quantifiable data in models to better reflect concerns of user groups, c) how risk and uncertainty are modeled and used by user groups and decision makers, d) the use of multicriteria decision tools that are user friendly and responsive to user and management's needs and e) integrate the sampling and growth-and-yield simulation investments with forest management decisions in a unified model. Progress on these topics will help ensure that operations research models remain a central high priority for future natural resource managers and users.

Competing Interest Statement

The authors declare no competing interests.

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Appendix A: History of Systems Analysis in Forest Resources Symposia

Table 1: History of Systems Analysis in Forest Resources Symposia

No	Date	Venue	Publisher	Pap.	Proc.	Symposium Title
1	Aug 11-13 1975	Univ. of Georgia, Athens, GA	Society of American Foresters	38	Yes	Systems Analysis and Forest Resource Management
2	Dec 9-11 1985	Univ. of Georgia, Athens, GA	GA Ctr for Continuing Educ. (1987)	49	Yes	1985 Symposium on Systems Analysis in Forest Resources
3	Mar 29 - Apr 1 1988	Asilomar Conf. Ctr, Pacific Grove, CA	USDA, FS, Rocky Mtn For Expt Sta, GTR-RM-161 (1988) `https://archive.org/details/CAT89912874/page/n5/mode/2up`	40	Yes	1988 Symposium on Systems Analysis in Forest Resources
4	Mar 3-6 1991	Charleston, SC	USDA, FS, SE For Expt Sta GTR-SE-74 (1991) `https://www.fs.usda.gov/research/treesearch/924`	65	Yes	1991 Symposium on Systems Analysis in Forest Resources
5	Mar 9-12 1993	Villa del Rio Conf. Ctr, Valdivia, CL	Austral Univ Valdivia, Chile (1994)	48	Yes	Int'l Symposium on Systems Analysis and
6	Sep 6-9 1994	Asilomar Conf. Ctr, Pacific Grove, CA	Society of American Foresters `https://faculty.washington.edu/bare/1994%20SSAFR%20Symposium.pdf`	49	Yes	1994 Symposium on Systems Analysis in Forest Resources
7	May 28-31 1997	Shanty Creek Resort, Traverse City, MI	USDA, FS, NC For Expt Sta GTR-NC-205 `https://www.nrs.fs.usda.gov/pubs/gtr/other/gtr-nc205/index.html`	65	Yes	Seventh Symposium on Systems Analysis in Forest Resources
8	Sep 27-30 2000	Snow Mass Village, Aspen, CO	Kluwer Academic Publishers, The Netherlands, (2003) `http://www.springer.com/life+sciences/forestry/book/978-90-481-6280-2`	31	Yes	Systems Analysis in Forest Resources
9	Mar 4-7 2002	Punta de Tralca, Chile	Int'l J of OR Vol 10(5): 409-542 (2003) `http://www.dii.uchile.cl/~sympfor/CD/index2.html`	51	Yes (select pap. & abst.)	Symposium on Models and Systems in Forestry

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No	Date	Venue	Publisher	Pap.	Proc.	Symposium Title
10	Oct 7-9 2003	Skamania Lodge, Stevenson, WA	USDA, FS, PNW For Expt Sta GTR-PNW-656 (2005) https://www.fs.usda.gov/pnw/pubs/pnw_gtr656.pdf	42	Yes	Systems Analysis in Forest Resources: Proceedings of the 2003 Symposium
11	Sep 18-21 2005	Recanto das Toninhas Hotel, Ubatuba, Brazil	Serie Tecnica, Inst. de Pesquisas e Estudos Florestals, Issue No. 35 http://www.ipef.br/publicacoes/stecnica/nr35.aspx	58	Yes (partial w/abs)	Proceedings of the 3rd Iberian Am. Symposium on For Management and Economics and 11th SSAFR
12	Sep 5-8 2006	Inn at Essex, Burlington, VT	List of papers: http://faculty.washington.edu/bare/2006SSAFRprogram.pdf	45	No	12th Symposium for Sys Anal in Forest Resources
13	May 26-29 2009	Frances Marion Hotel, Charleston, SC	Int'l J of Math and Computational For and Nat'l-Res Sci Vol 2, Nos. 1 and 2 http://mcfns.com/index.php/Journal/article/view/MCFNS.2-41/MCFNS_2%3A41-42 http://mcfns.com/index.php/Journal/article/view/MCFNS.2-31	35	Yes (four select papers)	Outcomes of the 2009 Symposium on Systems Analysis in Forest Resources
14	Mar 8-11 2011	Marbella Resort, Maitencillo, Chile	Presentations at: http://faculty.washington.edu/bare/SSAFR2011	85	Yes (abstr. only, sel. pap. in Ann. Op. Res.)	14th Symposium for Systems Analysis in Forest Resources
15	Aug 19-21 2013	Hotel Chateau Laurier, Quebec City, Canada	Presentations at: https://faculty.washington.edu/bare/15thSSAFRProgram.pdf	68	Yes (abstr. & most pap.)	15th Symposium for Systems Analysis in Forest Resources
16	Aug 19-21 2015	Uppsala, Sweden	https://faculty.washington.edu/bare/uppsala15-ssafr-report.doc	77	Yes (abstr. only)	16th Symposium for Systems Analysis in Forest Resources https://faculty.washington.edu/bare/16thssafr-conference-program-and-information.pdf Report available as well.

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No	Date	Venue	Publisher	Pap.	Proc.	Symposium Title
17	Aug 27-30 2017	Clearwater Resort and Casino, Suquamish, WA	Oxford Press and the Society of American Foresters https://faculty.washington.edu/bare/suquamish17-SSAFR2017-report.doc	95	Yes (8 pap. sel.) Special Edition of Forest Science	17th Symposium on Systems Analysis in Forest Resources https://academic.oup.com/forestscience/article/66/4/424/5867208 Report available here.
18	Mar 3-7 2019	Puerto Varas, Chile	Natural Resource Modeling 6 selected papers in Vol 34, Issue 1 https://ssafr2019.cl/13/en/program	70	Program/paper titles	18th Symposium on Systems Analysis in Forest Resources
19	Jul 24-27 2022	Estes Park, CO	https://faculty.washington.edu/bare/ssafr22-report.doc	73	Yes (abstr. only)	19th Symposium on Systems Analysis in Forest Resources https://faculty.washington.edu/bare/19th%20SSAFR%20Program.pdf Report available here.
20	May 13-17 2024	Hotel Jaizkibel, Hondarribia, Basque Country, Spain	https://faculty.washington.edu/bare/AgendaSSAFR2024_version28042024.pdf	90	Yes (abstr. only)	20th Symposium on Systems Analysis in Forest Resources

Table 2: History of Systems Analysis in Forest Resources Symposia (cont)

No	Sponsors	Editors	Main Topics Addressed
1	Systems Analysis Working Group, SAF; SE For Expt Sta, USFS; Schl For Res, U of GA	John Meadows Bruce Bare Ken Ware Clark Row	Overview Multiple-use and land-use planning Timber management Harvesting and transportation Fire (see comment)
2	Systems Analysis Working Group, SAF; Schl For Res, U of GA; USDA, Forest Service; ORSA; TIMS	Peter Dress Richard Field	The use of FORPLAN in national forest planning Econometrics, regional analysis, and I/O analysis Dynamic programming Multiple criteria optimization Optimal control (see comment)
3	Dept of Forestry & Res. Mgt, U of CA; Systems Analysis Working Group, SAF; USDA, Rocky Mtn For Expt Sta; USDA, Land Mgt Planning	Brian Kent Larry Davis	FORPLAN and forest planning Timber harvesting and spatial planning Stand-level optimization and analysis Risk and stochastic analysis Multiple use and multicriterion analysis (see comment)
4	Systems Analysis Working Group, SAF; USDA, SE For Expt Sta; Westvaco; NC State University; For Products Res Society; TIMS	Marilyn Buford	Ecological and climate impacts modeling Harvest scheduling and spatial analysis Wood and paper processing Timber supply and price modeling Growth and yield modeling Fire protection and control and miscellaneous
5	For Mgt Inst., Univ. Austral of Chile; Dept of Ind Engr, Univ. Of Chile	Gonzalo Paredes	Forest and transportation planning Fire protection and planning Tactical planning and adjacency constraints Forest valuation, taxes, and industry profitability Manufacturing and log production (see comment)
6	Systems Analysis Working Group, SAF; Dept of For Engr and For Res, OR St Univ; USDA, FS	John Sessions Douglas Brodie	Ecological management International applications Tools for ecosystem mgt Risk analysis

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No	Sponsors	Editors	Main Topics Addressed
			Forest and environmental concerns (see comment)
7	Systems Analysis Working Group, SAF; MI St University; USDA, NC For Expt Sta	Michael Vasievich Jeremy Fried Larry Leefers	Spatial, Landscape, and hierarchical analyses Land use Wildlife and biodiversity Sustainability Decision support systems (see comment)
8	Systems Analysis Working Group, SAF; USDA, Pac SW For Expt Sta, Fire Lab; USDA, Rocky Mtn For Expt Sta; Yale School of For and Environment; USDA, FIA, Pac NW For Expt Sta	Greg Arthaud Tara Barrett	Fire and fuels Networks and transportation Forest and landscape planning Ecological modeling, biodiversity, and wildlife Forest resource applications
9	IFORS; IUFRO (Sec 5.13); Dept of Ind Engr, Univ. of Chile; Ctr for Math Modeling, Univ. of Chile	Robert Haight Andres Weintraub	Managing forest plantations Managing biodiversity and wildlife Modeling natural areas Structuring spatial relationships in forestry (see comment)
10	Systems Anal, For Econ, Policy, Law; Tech Assessment and Future Anal; Working Groups, SAF; IUFRO; College of Forestry and Dept of Stat, OSU; Western For and Cons Association; USDA, FS, PNW For Expt Sta, FIA Unit; Rocky Mth For Expt Sta	Michael Bevers Tara Barrett	Sustainability, criteria and indicators, and assessment Techniques and DSS for forest planning Forest assessment and planning case studies Fire suppression, fire planning, and fuel management Stand optimization and harvest operations (see comment)
11		Luiz Rodriguez	Forest Economics (modeling, marketing, supply and demand) Forest Management (spatial, landscape, hierarchical analysis) Land Use Planning and Collaborative Management Wildlife and Biodiversity applications Fuels, Fire and Biomass decisionmaking (see comment)

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No	Sponsors	Editors	Main Topics Addressed
12	Arkansas Forest Resources Center		Spatial forest planning Forest assessments Forest planning Road management and logistics Stand management (see comment)
13	Society of American Foresters; ArborGen; North Carolina State University	Marc McDill	Fire management planning Spatial planning with adjacency constraints Multiobjective auction-based planning model Hierarchial multiobjective harvest planning model
14	Instituto Sistemas Complejos de Ingenieria; Iniciativa Cientifica Milenio; Comision Nacional de Investigacion; Centifica Tecnologica; Facultad de Ciencias Fisicas Matematicas; and Ingenieria Industrial, Univ. de Chile; Forestal Mininco; Arauco; INFORMS; EURO	Andres Weintraub	Environment Long range planning Transportation and logistics Spatial planning Fire management Stochastic models Stand level modeling
15	Sponsors: FIBRE, NSERC-CRSNG, FPInnovations, CRiQ; Organizers: Univ. of Laval, FOR@C, Canada Research Chairs in; Planning Sustainable Forest Value Networks & Operations; Research in Natural Resources, Value Chain Optimization NSERC; and CIRRELT; Sophie D'Amours, Mikael Ronnqvist & Marc-Andre Carle, Chairs	Sophie D'Amours Mikael Ronnqvist Marc-Andre Carle	Supply chains and value chain optimization workshops Hierarchical planning models Forest ecology, biodiversity, and environment Forest operations and transportation Forest management and policy Growth and yield modelling (see comment)
16	SkogForsk, Swedish University of Agricultural Sciences; Charlotte Bengtsson & Ljusk Ola Eriksson, Chairs	Gert Andersson Lusk-Ola Eriksson Karin Andersson Fredrik Staland	Forest-based sector Planning and control in forest-based supply chains OR/MS techniques in forest planning MCDA methods (see comment)
17	Org. for Econ. Cooper. & Develop.; Coop. Res. Prog.: Bio. Res. Manage. for Sustain. Agri. Sys.; Univ of Washington Prec. For. Coop; E.U. Marie Curie Prog. for Sci. Staff Exchange; IUFRO, USDI Bureau of Land Management; WA Dept of Natural Resources, Soc of Am Foresters; WA Farm Forestry Association; Sandor F. Toth and L. Monika Moskal, Chairs	Sandor F Toth	Wildfire management Remote sensing Supply chain optimization Forest economics and management models Modeling uncertainty Forest operations and transportation

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No	Sponsors	Editors	Main Topics Addressed
18	Instituto Sistemas Complejos de Ingenieria; SuFoRun; Univ of Washington Precision Forestry Cooperative; Andres Weintraub and Sandor Toth, Chairs	Andres Weintraub	Harvest scheduling Forest operations and transportation Forest industry Bioenergy logistics (see comment)
19	DecisionES; IUFRO; Colorado State University; Yu Wei and Sandor Toth, Chairs	Yu Wei	Forest, watershed and land management planning Forest transportation, routing, and supply chain optimization Fire risk reduction, AI management, detection, and DSS Forest health, invasive species, and wildlife habitat management Biomass transport scheduling and DSS Ecosystem services, MCDM, and carbon management (see comment)
20	IUFRO; DecisionES Consortium; FIRE-RES; FORPLADEM; Forests Monitor	Jordi Garcia-Gonzalo	Application of Remote Sensing in Forestry Forest Modelling Forest management and planning Forest transportation and supply chain optimization Wildfire risk simulation, management, and decision support Forest health, invasive species, and wildlife habitat management Spatially explicit optimization Stochastic process simulation and optimization Quantitative forest and fire economics Forest and watershed management Data science and machine learning Forest systems analysis under the impact of climate change