

Contents

1	Introduction	1
2	A Multicriteria Optimization Model for Forestry Management under Climate Change Uncertainty: An application in Portugal	2
2.1	Introduction and Motivation	4
2.1.1	Our Contribution and Outline of the Paper	5
2.2	Stochastic Goal Based Approach for Harvesting Management	5
2.2.1	Preliminaries: Goal Programming and Stochastic Programming	6
2.2.2	The Stochastic Goal-Based Harvesting Problem	6
2.2.3	A Procedure for Calculating Robust Target Values	9
2.3	Computational Results for the SGH: An Application in Portugal	10
2.3.1	Case Study: a Forest in Portugal	10
2.4	Efficiency Analysis, Trade-offs and the Effect of Uncertainty	14
2.5	Hedging Against Worst Case: SGH combined with CVaR	20
2.5.1	Constraining CVaR	22
2.5.2	Reducing Worst-Case Shortfalls via CVaR Approach	22
2.6	Conclusions and Future Work	26
3	References	27
4	Appendix	30
4.1	Complementary Results for SGH	30

List of figures

1	Block diagram of the decision-making tool	10
2	Scenario-tree of the 32 climate change scenarios	12
3	Block diagram of the scenario-based parameter values	13
4	Pareto fronts of $\overline{C_S}$ v/s \overline{NPV} for different values of w_{EW} and $w_{KW} = \{0.0, 0.1\}$	16
5	Pareto fronts of $\overline{C_S}$ v/s \overline{NPV} for different values of w_{EW} and $w_{KW} = \{0.2, 0.3, 0.4, 0.5\}$	17
6	Boxplots of \overline{NPV} and $\overline{d_{NPV}}$ for different values of w_{NPV}	20
7	Boxplots of \overline{NPV} and $\overline{d_{NPV}}$ for different values of w_{NPV}	23
8	Boxplots of \overline{NPV} and $\overline{d_{NPV}}$ for different values of w_{NPV}	24
9	Pareto fronts of $\overline{CO_2}$ v/s \overline{NPV} using the two proposed risk-averse CVaR-based models.	25
10	Boxplots of $\overline{CO_2}$ and $\overline{d_{CO_2}}$ for different values of w_{CO_2}	30
11	Boxplots of \overline{EW} and $\overline{d_{EW}}$ for different values of w_{EW}	30
12	Boxplots of \overline{KW} and $\overline{d_{KW}}$ for different values of w_{KW}	31

List of tables

1	Values of $\Pi(X(\Omega))$ (measured as %) corresponding to different values of w_q	18
2	Values of average performances (\overline{NPV} , $\overline{C_S}$, \overline{RW} , \overline{WUE}) corresponding to different values of w_q	19
3	Values (in MM€) of the average performance \overline{NPV} obtained for the different models.	24

Glossary

- Stand: a forest unit land to manage.
- Strata: a group of various stands that share common characteristics such as species and age.
- NPV: acronym associated with Net Present Value criterion.
- CO₂: acronym associated with total carbon retention criterion.
- EW: acronym associated with runoff (Excess Water) criterion.
- KW: acronym associated with the efficiency of water use for biomass production criterion.
- GP: Goal Programming.
- SP: Stochastic Programming.
- SGH: Stochastic Goal-Based Harvesting Problem.
- CVaR: Conditional-Value-at-Risk.
- RASGH: Risk-Averse SGH.
- CVaRSGH: CVaR-constrained SGH.