AREC 615: Project Proposal

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Linear programming approach for optimal forest plantation

1. Full Citation of Chosen Article

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2. Summary of the Original Paper

This paper addresses the challenge of achieving **economic efficiency** in forest plantation management, specifically focusing on the Shafaroud Forest in Iran. The core objective was to determine the optimal species mix and area allocation (in hectares) that would **maximize the Net Present Value (NPV)** of the entire project. The model considered five candidate species (Oak, Elm, Ash, Maple, Bald Cypress) constrained by soil suitability (Pseudogley and Forest Brown), cost, and labor limits. The original deterministic LP model established a baseline maximum profit ($\mathbf{3,521,115}$ ten thousands Rials) by allocating land solely to **Bald Cypress** and **Maple**. Crucially, the analysis concluded that the project's profitability was restricted only by the **Land Area** constraints.

3. Explanation of the Optimization Methods

The project utilizes a two-part optimization approach:

- **Linear Programming (LP):** Used for the primary task of **continuous area allocation**. The decision variables (X_i) represent the area (in hectares) allocated to each species.
- **Integer Linear Programming (ILP):** Used for **discrete selection**. The variables (X_i) are restricted to **binary** values ($\{0,1\}$) to confirm the optimal species choice.

The model's objective is to maximize $Z = \sum \mathrm{NPV}_i X_i$. The key economic metric derived is the **Shadow Price (Dual Price)**, which quantifies the marginal economic value of a scarce resource for guiding policy.

4. Description of Intended Extension: Water Scarcity

The extension implements a **policy-relevant constraint modification** to address the critical environmental factor of water scarcity, which the original model neglected.

Implementation

1. **New Constraint:** Introduce a binding **Water Consumption Constraint ($\mathbf{C10}$)**, setting a strict total budget limit of $W_{\max} = 300$ units. The constraint uses estimated coefficients based on relative water efficiency ($\mathbf{0.5}$ for Bald Cypress, $\mathbf{1.5}$ for Maple/Ash).
2. **Model Adjustment:** The contradictory **Minimum Labor ($\mathbf{C5}$)** and **Minimum NPV ($\mathbf{C8}$)** constraints are removed to ensure the model remains mathematically feasible under the new tight water budget.

Expected Outcomes and Economic Application

The extension is designed to quantify the economic consequences of this environmental policy:

- **Quantify Policy Cost:** Calculate the drop in total NPV (NPV Reduction), which is the direct economic cost of enforcing the water conservation policy.
- **Resource Valuation:** Derive the **Shadow Price of water**. This figure assigns a tangible economic value to the scarce resource, providing managers with the precise amount they are justified in spending on water conservation or supply to maximize project profit.

#Appendix

```r
library(knitr)
knitr::opts_chunk$set(echo = FALSE)
knitr::opts_chunk$set(message = FALSE)
```