DEVELOPING PRIMER TRANSPORTATION PLAN FOR FORESTED AREAS UNDER THE RISK OF WINTER STORM DAMAGE

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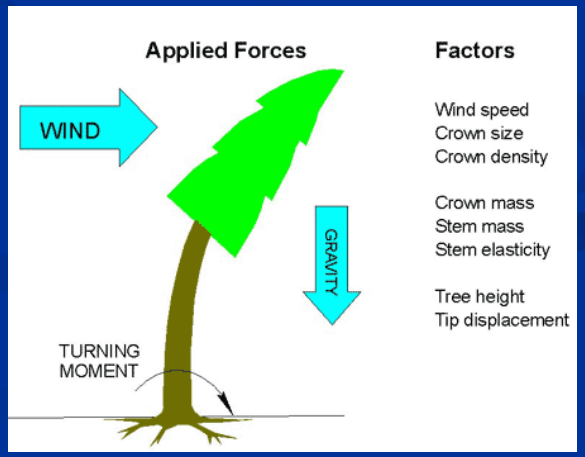
BACKGROUND

- Abiotic and biotic factors causing damages on forest tress also threat sustainability of forest resources.
- The wind damage is one of the most effective factors among the abiotic factors in Turkey.
- The severity of storm damage generally depends on; stand structures, topographical characteristics, climatic parameters, soil types, and soil depth.

BACKGROUND

- In order to minimize negative effects of winter storms on forest resources, the areas with high storm damage risk should be determined based on these factors.
- GIS based mathematical models can be effectively used in solving such problems.
- Once the areas with storm risk are determined, necessary strategies should be developed and implemented in the field.
- The silvicultural activities should utilize suitable logging techniques after storm damage.



BACKGROUND

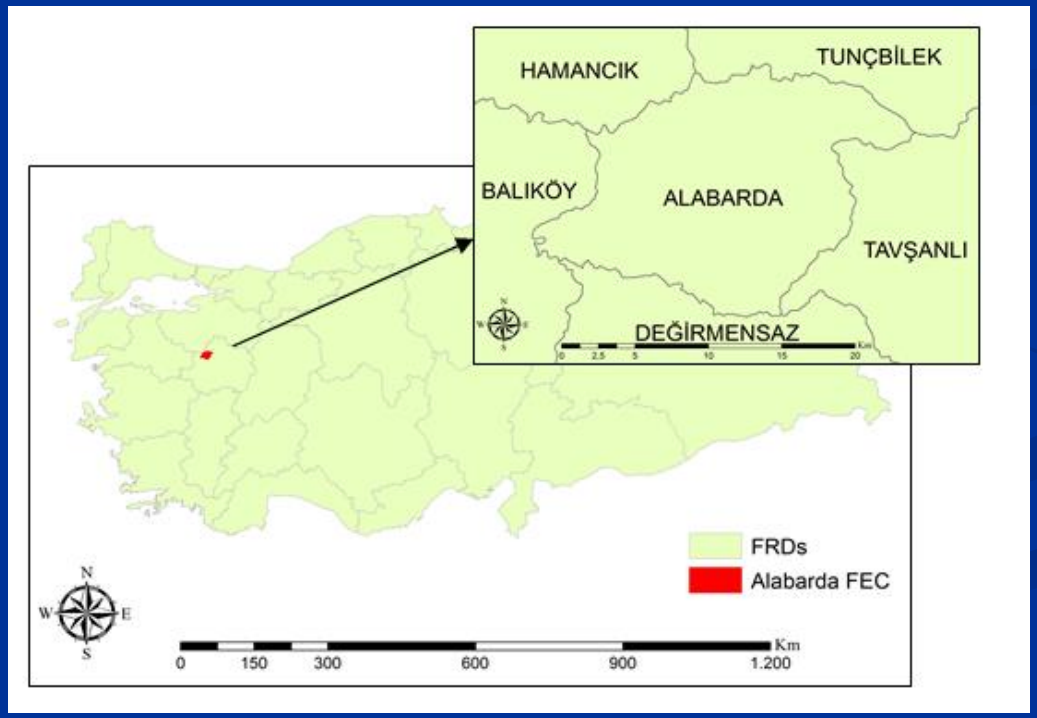
- The salvage logging operations after winter storm damage can be very difficult and costly tasks, and they may cause additional impacts on forest ecosystem.
- Besides, they are considered as one of the most dangerous forest operations involving serious safety and health problems.
- Therefore, primer transportation plan should be well planned considering economic, ecological, and work safety factors.

OBJECTIVE

- This study aimed to develop primer timber transportation plan for the areas with the risk of winter storm damage.
- GIS integrated mathematical model was used based on previously generated storm damage risk map.
- The terrain conditions and soil type were main factors in selection of transportation methods.

MATERIAL AND METHODS

- The study was implemented in Alabarda Forest Enterprise Chief (FEC) within the borders of Kütahya Forest Regional Directorate (FRD).
- In Alabarda FEC, serious winter storm damage was encountered in winter of 2015.



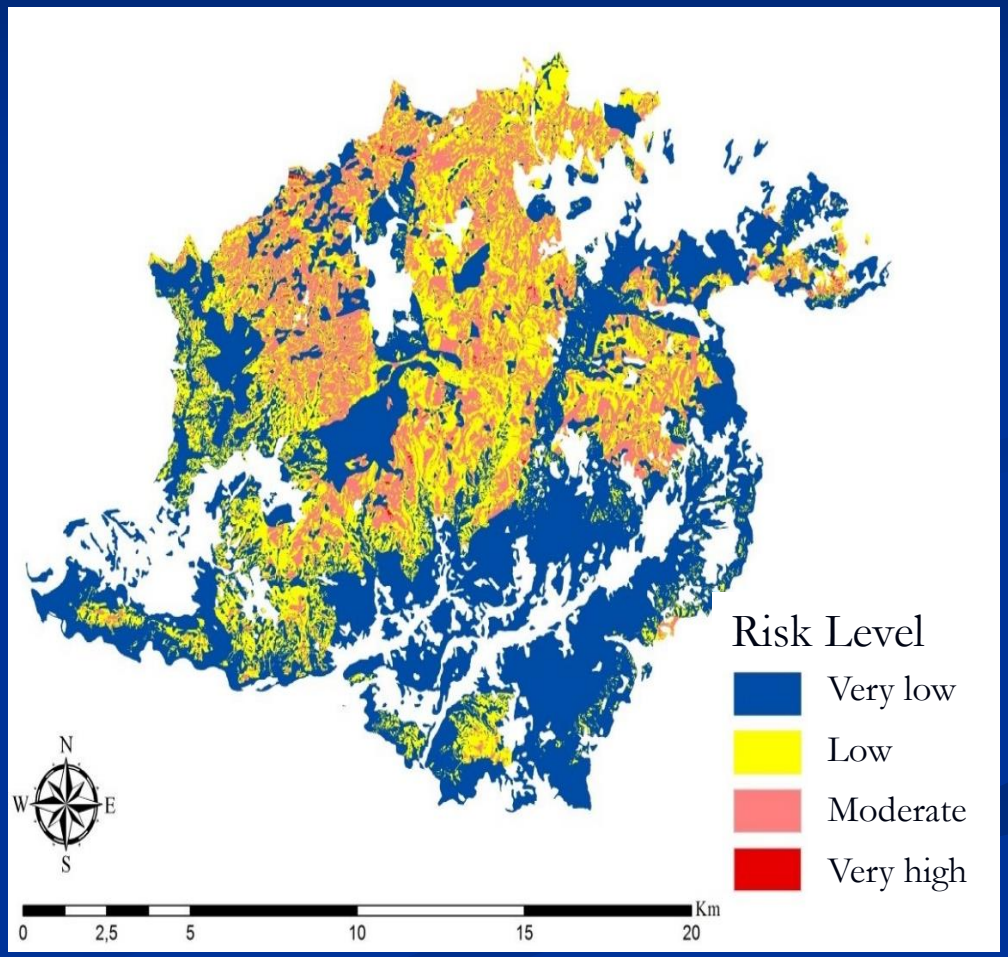
MATERIAL AND METHODS

- The dominant tree species in the area include Black pine, Brutian pine, Oaks, and other deciduous trees.
- The average elevation and ground slope are 900 m and 25%, respectively.
- About 200 thousand m^3 of salvage timbers are scheduled to be extracted from the area.

MATERIAL AND METHODS

Risk Map of Winter Storm Damage

- The risk map of storm damage was developed by using GIS based mathematical model (Fuzzy Logic).
- The risk factors of wind damage included tree species, tree age, crown density, site quality, topographical features (elevation, slope, aspect), climatic parameters (wind, precipitation), and soil depth.
- The study area was divided into four risk zones including high, moderate, low, and very low risky areas.



MATERIAL AND METHODS

Optimum Transportation Plan

- Optimum primer transportation plan was developed by Analytic Hierarchy Process (AHP) approach.
- In the solution process, AHP method evaluated four alternative logging methods implementing cable logging, chute system, skidder, and farm tractor.
- The primer transportation plan was investigated based on three main criteria including storm damage risk map, terrain conditions (slope), and soil type.
- The detail information about risk map (10 m x 10 m) generation can be obtained from İnanç (2017).

MATERIAL AND METHODS

- Slope map of the study area was generated based on DEM and reclassified into five classes according to IUFRO slope classification suggested for logging operations.

Slope Classes	Ground Slope (%)
Gentle and low	0–20
Medium	21–33
High	34–50
Steep	> 50

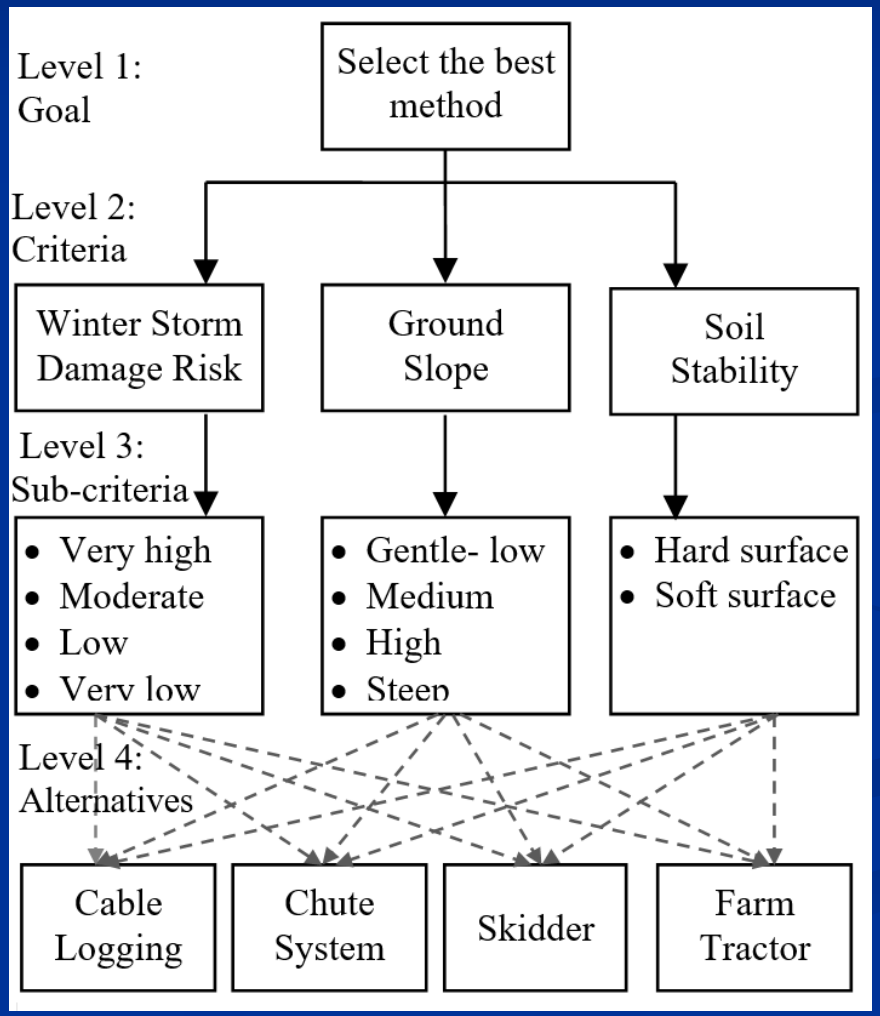
- The gentle and low slope classes were combined into a single slope class (0-20%). Thus, slope map was divided into 4 classes.

MATERIAL AND METHODS

- The stability of the soil is one of the most important limiting factors for ground-based mechanized logging operations.
- The impact of logging equipment increases on unstable and soft soils.
- Besides, mobility of the equipment is negatively affected by soft surface soil.
- The soil type map indicating stability of the surface soil was generated based on geological map of the study area.
- The soil data layer was then reclassified into two classes including stable and unstable soils.

MATERIAL AND METHODS

- The hierarchy of AHP implemented in this study



MATERIAL AND METHODS

- **The AHP generates a weight for each criterion based on decision maker's pairwise comparisons.**
- **The relative importance between two criteria is measured according to a numerical scale from 1 to 9.**

Intensity of Importance	Interpretation
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments

MATERIAL AND METHODS

- In order to compute the weights for the different criteria (or sub-criteria), a pairwise comparison matrix A was generated.
- In the next stage, normalized pairwise comparison matrix was generated.
- Then, weighted averages of the criteria (wj) were computed by averaging the entries on each row:

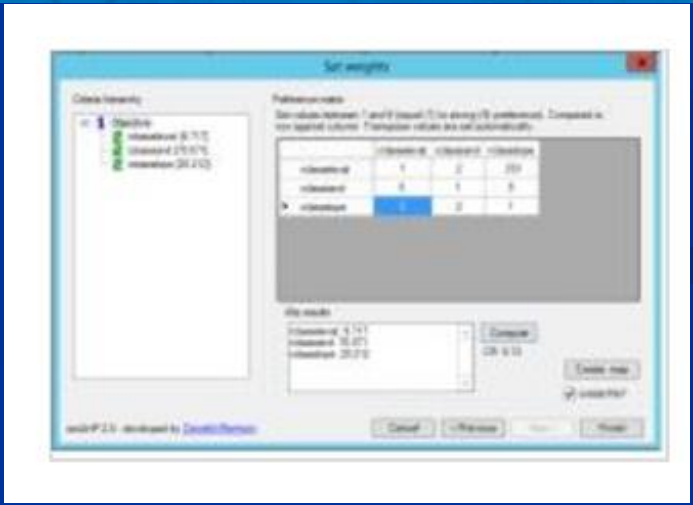
$$w_j = \frac{\sum_{i=1}^{n} c_{ji}}{n}$$

- The ratio of Consistency Index (CI) and Random Index (RI) were computed to control the consistency.
- After checking the consistency, “Reclassify” tool of ArcGIS 10.2 was used to assign weighted average values (wj) to the corresponding criteria.

MATERIAL AND METHODS

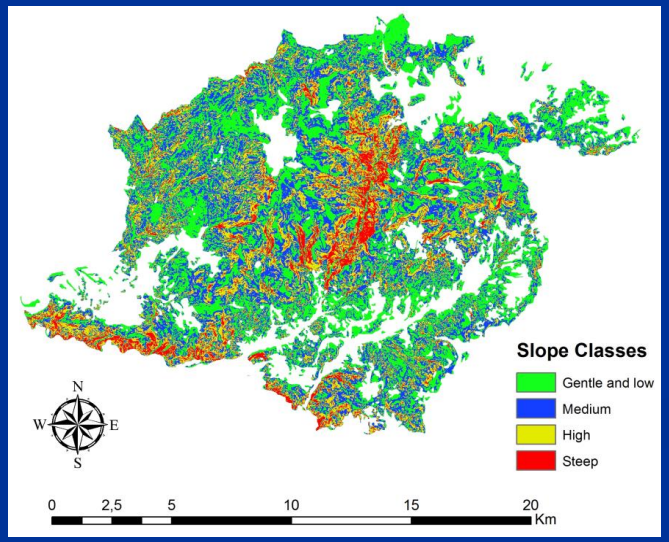
- The process was repeated for three alternative logging methods.
- Then, “extAhp 2.0” plug-in tool in ArcGIS was used to combine the weighted averages of the criteria and determine the AHP score for each logging method.
- Finally, the optimum logging method with the highest score was determined by a weighted sum of the scores with respect to all the criteria.

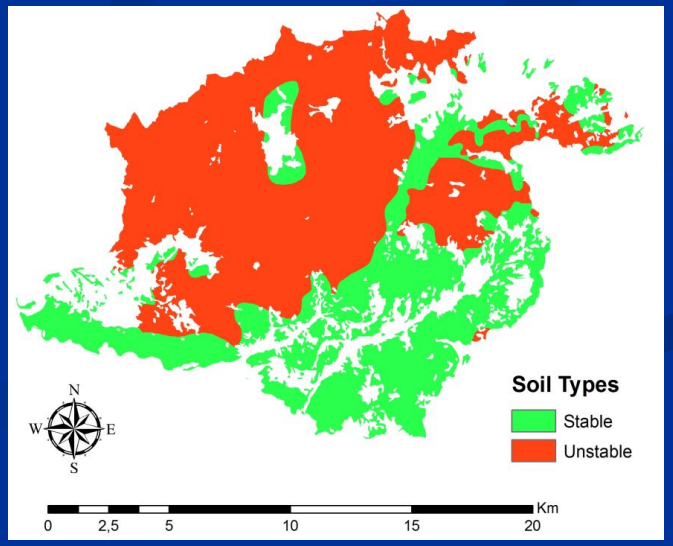
extAhp20 - Analytic Hierarchy Process for ArcGIS



RESULTS AND DISCUSSION

- Based on the risk map, 19% of the area was moderately risky, while 28% and 53% was low and very low, respectively.
- Very little area was classified as highly risky zones.
- 38% of the study area was on gentle and low slope classes, while 33% was on medium slope class.
- 22% of the area was at high slope, rest was on steep terrain.
- Soil was stable in 38% of the area, while rest was unstable.





RESULTS AND DISCUSSION

- The cable logging was suitable for the areas with high storm damage risk, while skidders were appropriate for the areas with moderate risk.
- The farm tractors and chute system were preferable for the areas with low and very low risk, respectively

The Risk Level	Cable Logging	Chute System	Skidder	Farm Tractor
Very low	0.06	0.58	0.08	0.25
Low	0.06	0.25	0.31	0.58
Moderate	0.35	0.08	0.54	0.08
High	0.53	0.08	0.08	0.08

The weighted values of storm damage risk

RESULTS AND DISCUSSION

- The cable logging was appropriate for steep terrain, while chute system was suitable for high slope classes.
- Ground-based equipment, skidder and farm tractor, were preferable for medium and gentle/low slope areas, respectively.

Slope Classes	Cable Logging	Chute System	Skidder	Farm Tractor
Gentle/low	0.07	0.07	0.13	0.64
Medium	0.07	0.20	0.60	0.21
High	0.21	0.60	0.20	0.07
Steep	0.64	0.13	0.07	0.07

Weighted values of slope (sub-criteria) for alternative logging methods

RESULTS AND DISCUSSION

- **Ground-based logging equipment were suitable for stable soil, while cable logging and chute system were appropriate for unstable soil surfaces.**

Soil Types	Cable Logging	Chute System	Skidder	Farm Tractor
Stable	0.42	0.30	0.90	0.80
Unstable	0.58	0.70	0.10	0.20

The weighted values of soil type

RESULTS AND DISCUSSION

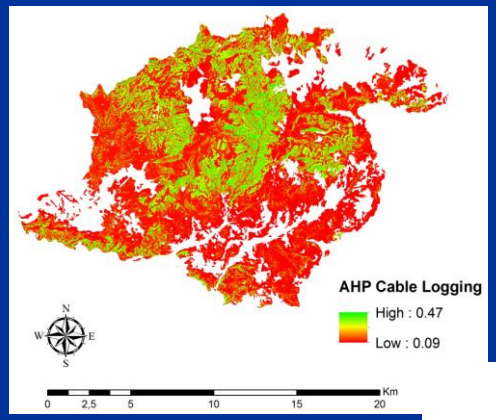
- **Then, the weighted averages of the criteria were combined for the alternatives and the score for each logging method was determined by using "extAhp 2.0" tool in ArcGIS 10.2.**

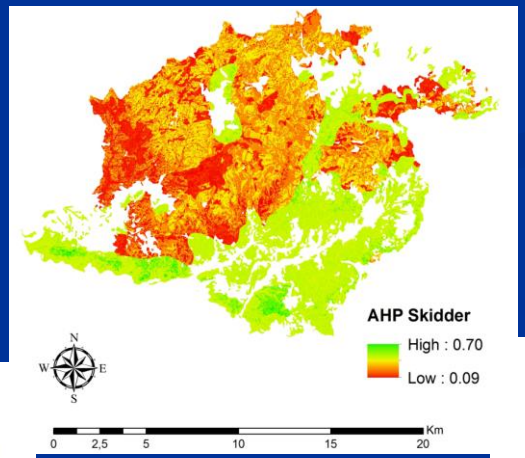
Criteria	Cable Logging	Chute System	Skidder	Farm Tractor
Storm Risk	0.57	0.50	0.50	0.50
Slope	0.36	0.38	0.08	0.13
Soil	0.07	0.13	0.42	0.38

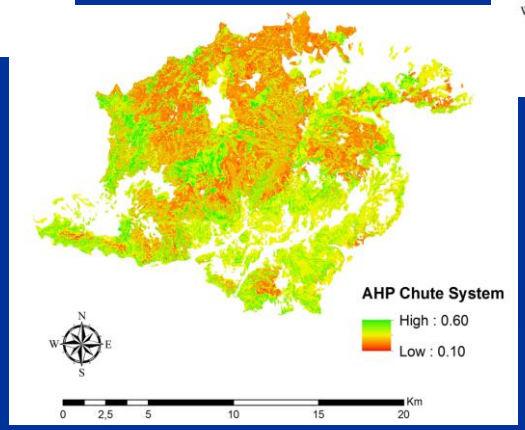
The weighted values of criteria

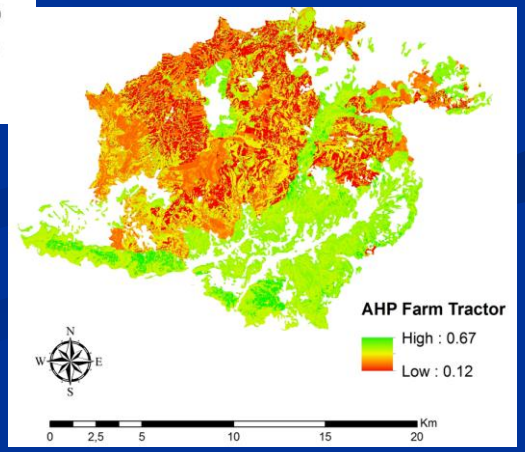
RESULTS AND DISCUSSION

- The result indicated that the most effective criterion was storm damage risk for all three alternatives.
- For cable logging and chute system, the importance of ground slope was higher than soil stability, while it was opposite for ground-based logging



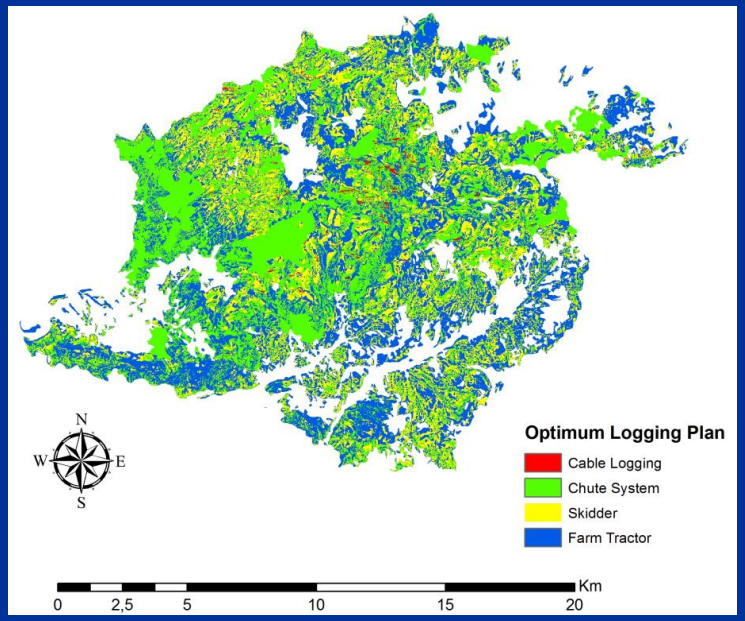






RESULTS AND DISCUSSION

- The results indicated that farm tractor method was suggested as optimum logging method for 40.5% of the study area.
- Chute system and skidder logging were the optimal methods for 35.5% and 23.4% of the study area, respectively.



The Risk Level	Cable Logging	Chute System	Skidder	Farm Tractor
Very low	0.00	46.75	18.63	34.62
Low	0.00	20.58	0.00	79.42
Moderate	2.07	26.98	70.95	0.00
High	100.00	0.00	0.00	0.00

CONCLUSIONS

- After winter storm damages, timber logging operations must be conducted quickly before the trees are deteriorated or lose economic value.

- Logging in storm damaged areas can be costly and very dangerous tasks. Besides, improper logging may cause even more impacts on forest ecosystems.

- GIS integrated AHP method was presented in this study to provide decision makers with quick and accurate solutions for primer transportation plans in storm damaged areas.

CONCLUSIONS

- For the moderately risky areas, skidder and chute systems are selected as optimum logging methods.
- On storm damaged stands, grapple skidders are suggested especially for extraction of large size timber.
- Chute systems are used to slide smaller size timber from uphill stands to landing areas.
- At the areas with low storm damage risks, mostly farm tractors and then chute system are suggested.
- The farm tractors modified for forestry operation can be used for skidding timber. On steep ground, farm tractors can be used for winching purposes.

Thank you for your attention…