

A STRATEGY FOR THE MANAGEMENT OF ABANDONED MOUNTAIN PASTURE LAND COLONISED BY DWARF PINE

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*The uncontrolled spread of naturally forested areas might in itself represent a problem. Such extensions often imply a loss of cultural landscapes and habitat variety, the depletion of bio- and ecodiversity, and territorial homogenisation accompanied by the loss of economic and natural resources. In the northern part of the Altopiano dei Sette Comuni, a plateau area in the Venetian Alps, dwarf pine (*Pinus mugo* Turra) has been the most invasive species and has had a high impact on the occupation of alpine pasture land, roads, paths and historical sites.*

This analysis considers the operational costs for the felling of dwarf pine stems, for the transport of the material to staging areas and for the chipping of the material at these areas. This logistic problem is broadly analysed using a GIS-based decision support system based on a network analysis model and assuming various scenarios associated with different levels of upgrade of the forest road network. Supply-cost curves are then constructed to analyse the total reclamation cost in terms of the quantities of wood material produced.

The study highlights the high operational costs for harvesting wood material. The actual supply-cost ranges from 52 € t⁻¹ to 143 € t⁻¹. It decreases, ranging from 52 € t⁻¹ to 107 € t⁻¹, only if the upgrade of the forest road network is assumed.

This work also highlights the problem that the financial measures adopted by the European Union, as well as by national and regional governments, seem not to be sufficient to counteract the phenomenon.

The opportunities for overcoming the economic constraints through the alternative use of the material in a small-scale process are considered.

Key words: woodchips; forest road network; GIS; dwarf pine.

Parole chiave: cippato; viabilità forestale; GIS; pino mugo.

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1. INTRODUCTION

Low-intensity agricultural practices, such as grazing, play a significant role in nature conservation in Europe. Many quasi-natural areas are in fact the product of some human influence, and the conservation of these areas depends entirely on the continuation of this influence (OSTERMANN, 1998).

The European Landscape Convention defines the landscape as “an area, as perceived by people, whose character is the results of the action and interaction of natural and/or human factors” (COUNCIL OF EUROPE, 2000), so that landscape protection implies “actions to con-

serve and maintain the significant or characteristic features of a landscape, justified by its heritage value derived from its natural configuration and/or from human activity”.

Even the Council Directive 92/43/EEC “on the conservation of natural habitats and of wild fauna and flora” (Habitat Directive) highlights that natural habitats are “terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural”. This statement means that “natural” habitats also include “semi-natural” areas, such as pastures, created and maintained by human activities.

Currently, the uncontrolled encroachment

of forests might itself represent a problem. It often implies a loss of cultural landscapes and habitat variety, the depletion of bio- and eco-diversity, and territorial homogenisation accompanied by the loss of economic and natural resources (CONTI and FAGARAZZI, 2004).

The invasion of subalpine areas by shrubs as a result of livestock reduction and the abandonment of pastures is a common process in the Northern Calcareous Alps (DIRNBÖCK and DULLINGER, 2008). Dwarf pine (*Pinus mugo* Turra) is particularly effective at invading subalpine and alpine non-forest sites (DIRNBÖCK and DULLINGER, 2008; DULLINGER *et al.*, 2003).

The abandonment of traditional grazing activities is seen to produce a change and reduction in valuable habitat types (OSTERMANN, 1998) and a loss of biodiversity (WATKINSON and ORMEROD, 2001; TALLOWIN *et al.*, 2005; MACDONALD *et al.*, 2000; PORNARO *et al.*, 2009).

Many studies have demonstrated (LINDSTÖM *et al.*, 1998; ZBINDEN *et al.*, 2003; ZEITLER, 2003) that the management of alpine pastures is a key factor for preserving most existing bird habitats. In the area considered in this study, a plateau in the Venetian Alps, the colonisation of pastures by shrubs affects the density and breeding success of black grouse (*Tetrao tetrix*). The capacity of the habitat to support black grouse depends on pasture management practices, such as the grazing, mowing, and control of regenerating trees and shrubs. The declining use and maintenance of alpine pastures leads to a reduction of black grouse populations (GLÄNZER, 1985).

In addition to its impacts on bio- and eco-diversity, the uncontrolled expansion of dwarf pine produces other negative effects, such as the invasion of historical sites and the overgrowth of forest roads and trails. The vegetation, if not controlled, may prevent vehicle traffic and make the areas inaccessible. A decline in accessibility will reduce the value of the area for tourism and thereby reduce the resources potentially available for environmental services. Moreover, it will decrease the efficiency with which the area can be managed.

One of the major constraints on the reclamation and correct management of the areas is the

high operational costs. To maintain the pasture areas and the forest roads in good condition, it is necessary to invest large amounts of time and money in operations that produce no apparent economic benefits.

A considerable proportion of the total cost originates from logistics-related activities (transportation, storing and handling) that are particularly difficult to accomplish under the conditions being considered. The productivity and cost associated with transportation depend on several factors, such as the type of material, the type of vehicle used for hauling and the characteristics of the road network (POTTIE and GUIMER, 1986). Logistic chain modelling is very important in improving the overall performance of the total logistic chain (SLATS *et al.*, 1995).

ArcGIS Network Analyst represents a valid tool for performing analyses and solving problems related to logistics. This tool allows the creation of an origin-destination (OD) cost matrix with multiple origins and multiple destinations. It includes network impedance values (such as travel time) for the routes from each origin to each destination. Additionally, it ranks the destinations connected with each origin in ascending order based on the minimum network impedance required to travel from that origin to each of the destinations. ArcGIS Network Analyst also provides a vehicle-routing problem solver that can be used to determine solutions for complex management tasks and that allows setting a series of descriptors (speed limits) and restrictions (barriers) for use in modelling transport activities on a road network. The problem solver's OD cost matrix is based on the Dykstra algorithm (DYKSTRA, 1984) for finding shortest paths (ESRI, 2009).

In this paper, a first approach to the reclamation of an area invaded by dwarf pine and the logistics of the associated operations are analysed, assuming the removal of the trees from two strips along the borders of the forest roads.

First, a preliminary investigation of the area and field trials were conducted to achieve the following objectives:

- Evaluate the extension of the surface covered by dwarf pine;

- Define the characteristics of the forest road network;
- Define the productivity of the dwarf pine felling operation.

In the second part of the work, the data collected were used to create a model for the transportation of the material under different scenarios (Figure 1). The model was used to:

- Evaluate the possible logistic solution;
- Evaluate the total cost of wood-chip production.

2. MATERIALS AND METHODS

2.1. Study area

The study area was located in the northern part of the Altopiano dei Sette Comuni in northeastern Italy (46-45.92° North latitude, 11.45-11.65° East longitude). The altitude ranges from 1 600 m to 2 341 m a.s.l.

The area is designated as a Special Protection Area (SPA code IT3220036) in the Natura 2000 Network under the Habitats and Birds

Directives. The majority of the area’s trees are dwarf pines. These pines form a sparse forest.

For centuries, the pastures were grazed by sheep and cows used the northern part of the area in the summer. Dwarf pine was regularly used for the production of charcoal during the 19th century. During the past fifty years, the demand for dwarf pine wood for charcoal production has decreased, and grassland previously used for pasture has been increasingly abandoned. These two processes have resulted in the initiation of colonisation by dwarf pine (Zovi, 2009).

The surface occupied by dwarf pine in the Vicenza Province, according to the Regional Map of Forest Types, is 2362 ha, of which 1398 ha (59%) are within the study area (REGIONE DEL VENETO, 2006).

For these reasons, the Altopiano dei Sette Comuni represents a meaningful case study of the effect of the expansion of dwarf pine forest into pastures, breeding areas and historical sites. These historical sites consist mainly of remains dating from the First World War.

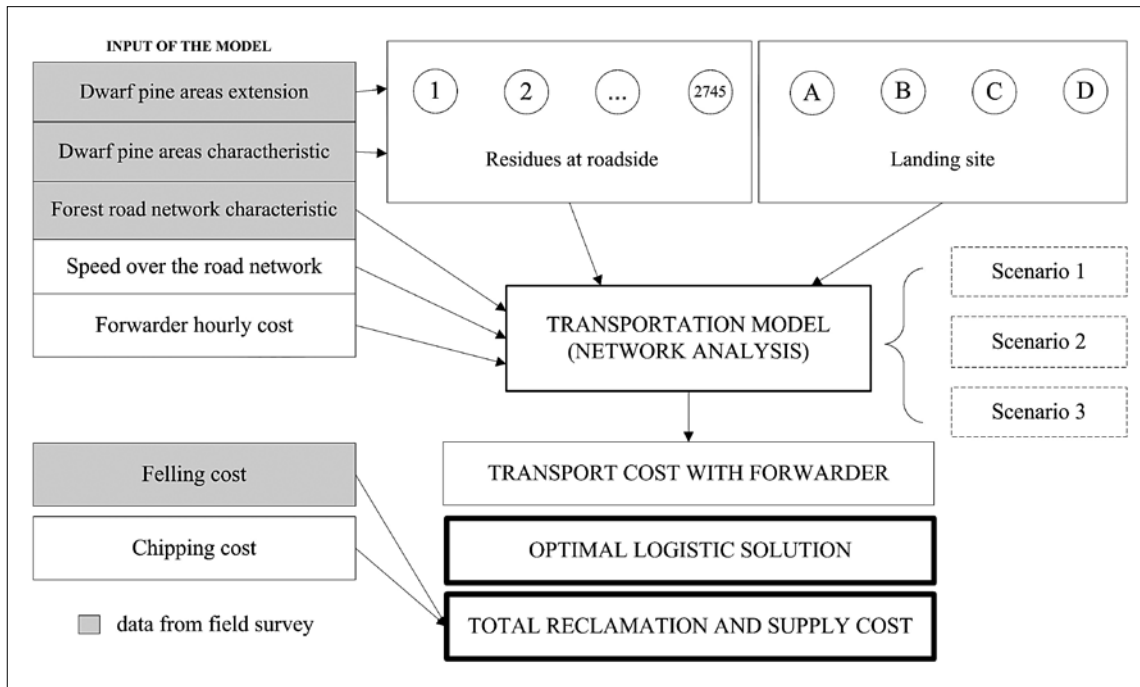


Figure 1 – Layout of the study.

2.2. Site analysis

A detailed survey of the area was conducted to analyse the overall situation and define a correct *modus operandi*.

First, the surface area occupied by dwarf pine reported on the Regional Regional Map of Forest Type was verified and redigitised through a detailed visual analysis of aerial photos and subsequent field validation.

To estimate the characteristics of the dwarf pine stands, five square plots (15 m x 15 m) were randomly selected in the study area. All the individuals of dwarf pine in each plot were sampled. The number of stems and the diameter of each stem were recorded for each tree. After the clearcutting of each sample plot, all the wood produced was weighed using a dynamometer (KERN HCB 50K20) and a wood trestle.

The number of trees was counted in each sample plot. The data also included the number of stems for each tree and the diameter and the weight of each stem. The weights were summed to obtain an estimate of the mean growing stock. The field trials were conducted in summer 2009.

The coverage and the characteristics of the area's forest road network were also surveyed.

A GPS survey was conducted to collect information about the dimensional characteristics of the forest road network. The classification used was based on the type of machine able to travel on the roads. The limiting width (traffic barriers) and the condition of the road were also surveyed.

The roads were assigned to four classes representing the risk of invasion by dwarf pine.

Potential staging areas were also identified.

A potential staging area should have suitable dimensions (>1500 m²) for piling and chipping the material and should be easily reachable by trucks for final transportation of the product.

2.3. Logistic organisation

The logistic chain considered for the case study is represented in Figure 2.

The three most important frames in the organisation of the operation are the piles of material on the roadside (directly connected with the locations of the dwarf pine areas and of the growing stock), the forest road network and the staging areas.

The distance (meters) along the road required to complete a forwarder load at each felling site (FS) was calculated using the following formula:

$$FS = L_{max} \times \frac{1}{GS} \times \frac{1}{LD} \quad [1]$$

where:

- FS characteristic length of the felling site
- GS mean value of the growing stock for the dwarf pine areas (in t m²);
- Lmax capacity of the forwarder for transporting wood material (t) (limited to 4 t because of volume limitation);
- LD lateral distance reachable by the forwarder crane (m) (assumed equal to 7.5 m on each side of the road).

Using this assumption and the information on the growing stock of the dwarf pine in the area, the distance along the road required to complete a load was calculated to be 20 m.

The characteristics of the forwarder used here were based on the technical data for a machine currently used in the area (HSM 208F 12t).

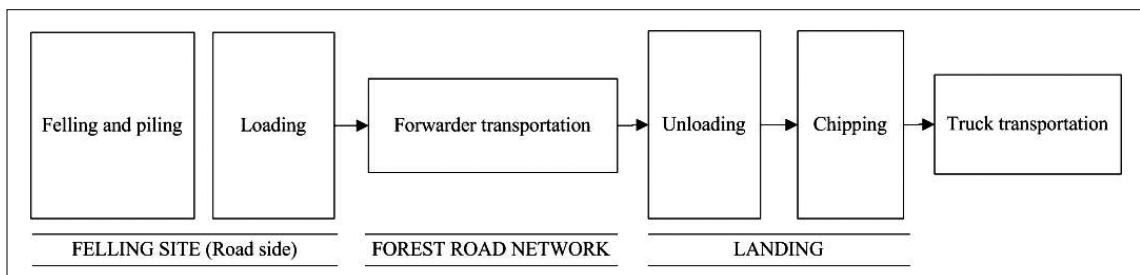


Figure 2 – Assumed logistic chain.

2.4. System of utilisation and cost analysis

The analysis of felling and stacking was based on the fact that the only effective way to fell dwarf pine is to employ one or more chainsaw operators. The characteristics of the stem do not permit the use of any other method.

A study of the use of time by the chainsaw operators was performed during the clearcutting of the 5 sample plots.

The total time (including delays) needed by a team of 2 chainsaw operators to completely clearcut and stack the material in each plot was used to determine the productivity of the operation.

The felling cost (Table 1) was then calculated by dividing the hourly cost of the operation by the hourly productivity.

The hourly cost of the chainsaw was calculated using the Miyata method (MIYATA, 1980). The hourly cost of the operator was fixed in accordance with the CCNL 2006.

The reclamation strategy chosen for the analysis was to fell all the material within 7.5 m of each side of the forest road. This distance was chosen because it is easily reachable from the road by the crane on the forwarder.

The transportation model assumed that a forwarder was used to extract the material. A forwarder was chosen for this purpose because it can be loaded and unloaded rapidly, because it can carry a large load and because it offers high speed and mobility on the forest road network.

The time required to drive from the felling sites to the staging areas was calculated in ArcGIS with the Network Analyst tool. Different average driving speeds were used for the forwarder according to the characteristics (width, slope) and the condition of the roads. A range of driving speeds between 8 and 12 km/h was adopted.

For each transportation cycle, fixed times for the loading and unloading operations were also considered. These times were estimated based on interviews with the forwarder operators and reflected the experience of the operators with the transportation of forest residues (mainly branches). The times selected were 30 min for the loading operation and 10 min for the unloading operation.

The transportation cost was calculated by multiplying the hourly cost of the forwarder by the time required to travel from the felling site to the staging area.

The hourly cost of the machine (Table 1) was determined by applying the Miyata method (MIYATA, 1980), using data furnished by a forest enterprise that used a forwarder for the operation considered by the study.

The chipping was assumed to occur at the staging area. A mobile chipper (JENZHEM 560 D) was selected for use. It was necessary for the chipping operation to occur immediately after felling and extraction to preserve the essential oils contained in the wood material. The chipping productivity was assumed to be $64 \text{ m}^3 \text{ h}^{-1}$ (NEGRIN, 2010), as evaluated in some field trials that examined the chipping of tree branches. The derived cost is reported in Table 1.

2.5. Scenario simulation

All of the data previously discussed were used to build a model to simulate the logistic cycle of the material from felling to chipping.

The inputs to the model consisted of the felling sites (FS - origin), the landing sites (LS - destination) and the forest road network.

A series of descriptors (speed limits) and restrictions (barriers) were superimposed on the forest network to simulate the characteristics of the road and the presence of features that limited the traffic at certain points.

The model calculates the transport cost by summing the times and costs of transport and of loading and unloading over the route between each origin (FS) and each destination (LS). The lowest cost required to reach each destination from each origin is determined from the resulting matrix. These minimum transport costs constitute the output of the model.

Table 1 – Operational cost.

Operation	Unit	Cost
Felling	$\text{€ } t^{-1} (w=50\%)$	11.8
	$\text{€ } ha^{-1}$	1633
Chipping	$\text{€ } t^{-1} (w=50\%)$	14.7
	$\text{€ } ha^{-1}$	2034
Forwarder transportation	$\text{€ } h^{-1}$	121

The scenarios simulated represented three different situations. Each scenario included a subset of inputs representative of the condition of the forest road network.

Scenario 1 represented the actual situation. Scenario 2 evaluated the potential influence of a new forest road whose construction would considerably reduce the mean transport distance. Scenario 3 calculated the change in transport cost that would result from a total upgrade of the forest road network, including the removal of all the traffic barriers. A total of 36 simulations were run.

The output data resulting from these simulations were used to choose the logistic solution that minimised the total transportation cost and to construct the supply-cost curve.

3. RESULTS

3.1. Extent and characteristics of areas invaded by dwarf pine

The extent of the areas covered by dwarf pine in the northern part of the Altopiano dei Sette Comuni has never been as great as it is today. This invasion by dwarf pine has become a major problem in the past decades.

Based on the interpretation of aerial photographs, an estimate of the surface area covered by dwarf pines is 1867 ha. The expansion of the dwarf pine area has been continuous and uncontrolled. The increase in the area covered by dwarf pine in the past 40 years has been estimated as 494 ha.

The results of the samples collected from the study plots are presented in Table 2 and reveal a mean growing stock of 138.4 t ha⁻¹.

The strategy for the reclamation of the forest roadside areas potentially involves an area of 25 ha (16.6 km of roads, with a 7.5 m buffer on each side of the road). The potential amount of felled material resulting from this strategy is approximately 3460 t, with a moisture content of total wood mass (*w*) equal to 50%.

In the actual situation, the traffic barriers that limit travel on the forest road network must also be considered. In this case, the area reclaimed becomes 20 ha and the material that is retrievable and transportable at the staging areas decreases to 2985 t (*w*=50%).

Assuming a rotation time of 25 years (BROLL and PIETROGIOVANNA, 2009), to guarantee a constant supply of material the reclamation should be conducted on 667 m of road per year (assuming a 7.5 m buffer on each side) with an amount of material equal to 138 t year⁻¹.

3.2. Forest road network situation and maintenance needs

The forest road density index in the area occupied by dwarf pine is 19 m ha⁻¹, a considerable value for an area lacking any particular productive significance. The mean road width is 2.8 m. The barriers that limit traffic are represented primarily by hairpin turns and by points at which landslides occur sporadically.

The considerable density of roads in the area is a consequence of historical events. The Altopiano dei Sette Comuni was affected by the events of the First World War. Battles occurred

Table 2 – Sample plot data.

	D _m		H _m	T _m	Growing stock
	Cm	S.D (+/-)	m	t	t ha ⁻¹
Plot 1	8.1	2.49	2.81	3.04	135.1
Plot 2	7.7	2.19	2.63	3.3	146.6
Plot 3	8.7	2.59	2.84	3.74	166.2
Plot 4	7.1	2.41	2.52	2.64	117.3
Plot 5	7.6	2.58	2.67	2.85	126.6
Mean	7.8	0.60	2.69 (+/- 0.13)	3.11 (+/- 0.43)	138.4 (+/- 18.94)

D_m = mean diameter; H_m = mean height; T_m = total mass

in succession for four years. The study area was once the location of the battlefront. Once established in this area, the front remained stable during the last three years of the war. Diffuse road networks were built on both sides of the front to supply the opposing armies. This diffuse network still maintains its efficiency and is used today for forest transportation and tourist access.

The portion of the forest road network included in the dwarf pine transportation model had a total length of 37 km. The roads were classified according to two traffic categories: roads suitable for truck traffic (24 km) and roads suitable only for forwarder traffic (13 km). The forest roads suitable only for tractor traffic were not considered because they would not have been useful for the hypothesised conditions of utilisation.

The condition of the network's roads varied. At the time of the survey, 12 km of road was in good condition, the condition of 16 km of road affected the efficiency of transportation only slightly, and transportation efficiency was heavily affected by condition in 8 km of road.

Approximately 21 km of the forest road network is vulnerable to dwarf pine invasion. Of these roads, approximately 4 km is already completely occupied by dwarf pine (Figure 3).

3.3. Operational cost

The cost of felling and stacking the material was 1633 € ha⁻¹. The total cost of clearcutting the entire area and leaving the material at the roadside was 40825 €. Because further processing of the material (i.e., the distillation of essential oils) was considered, it was necessary to add the transportation cost from the felling site to the staging area and the chipping cost to these other cost estimates. The sum of felling, transportation (including loading and unloading) and chipping costs indicates that in the actual situation, the total cost of woodchips would range from 52 € t⁻¹ to 143 € t⁻¹, with an average cost of 92 € t⁻¹. The simulation of the logistic cycle showed that under the present circumstances the best logistic solution would be to establish two staging areas at points A and B (Figure 4). With these staging areas in-



Figure 3 – Present condition of forest roads: a) susceptible to invasion; b) partly invaded by dwarf pine; c) completely invaded by dwarf pine.

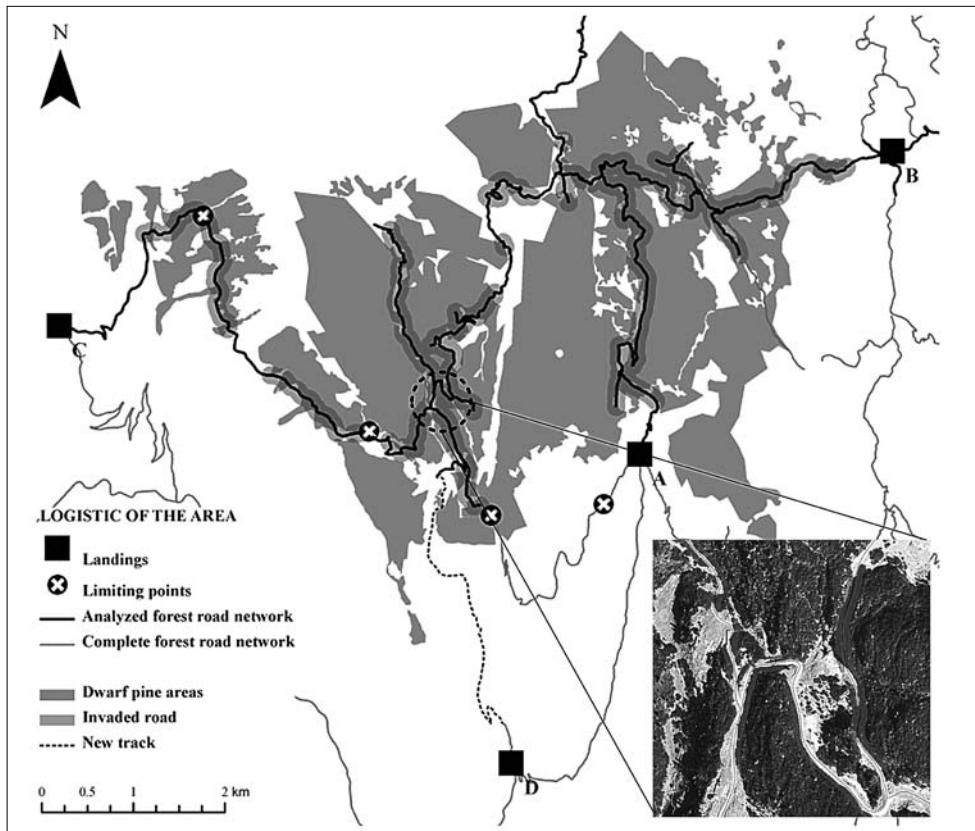


Figure 4 – Analysed area and road maintenance needs.

cluded in the overall strategy, the total reclamation cost, including transportation to the staging areas and subsequent chipping, would be approximately 500000 €.

The cost could, however, be reduced considerably by establishing a third site at point D. The inclusion of this site would require the construction of a new road (Figure 4) that would permit the forwarder to avoid a mountain that must presently be outflanked by using existing routes (Scenario 2). The average total cost in Scenario 2 then decreases to 68 € t⁻¹, with a range from 52 € t⁻¹ to 107 € t⁻¹.

The construction cost of a new forest road is estimated at 38.5 € m⁻¹ (CAVALLI and GRIGOLATO, 2010). The cost of upgrading a seriously deteriorated forest road is approximately 15 € m⁻¹. The total cost of developing the new forest road by improving an existing track for a distance of 1.7 km and constructing a new track 2 km long is estimated to be approximately

95500 €. The total reclamation cost would then decrease to 385000 €.

The upgrading of the entire forest road network would include the improvement of the surface condition of the roads to reduce travel time and the removal of traffic limitations. These measures would allow the addition of another staging area at point C (Figure 4). The model simulation in this case (Scenario 3) shows an increase of the available material to 3323 t, but the transportation cost does not decrease significantly. In Scenario 3, the average cost becomes 65 € t⁻¹ and ranges from 52 € t⁻¹ to 107 € t⁻¹.

If the entire forest road network is upgraded, the amount of surface area reclaimed increases to 25 ha, with a total reclamation cost equal to 444000 €.

Figure 5 displays the cost-supply curves resulting from the hypothesised logistic solutions (number of staging areas) for the different

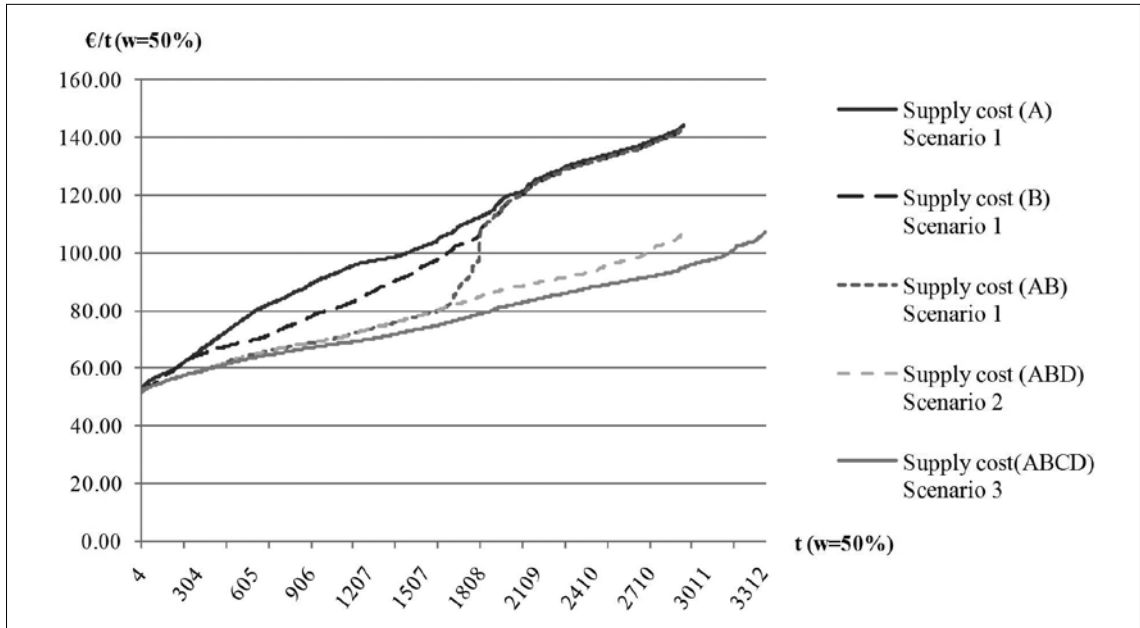


Figure 5 – Supply curves for different logistic scenarios.

scenarios. Each point of the cost-supply curve gives the average cost per ton of supplying different amounts of chipped material.

4. DISCUSSION AND CONCLUSION

The paper emphasises that the rapid expansion of dwarf pine is creating a serious problem in the study area. This invasive trend should be controlled, recognising that most of the benefits resulting from the intervention (improved bio- and ecodiversity, social and aesthetic gains) are not easily valued in economic terms.

Nevertheless, the present scope of intervention for reclamation of these areas is limited. The high operational costs represent a significant constraint, and the process is costly and time consuming. For this reason, the existing improved areas are very small and result from the efforts of game hunters or of the farmers directly involved in pasture management.

Moreover, financial measures, such as subsidies, incentives or compensation payments, represent the main tools so far adopted by the European Union as well as by national and regional governments to counteract marginalisa-

tion trends and land abandonment. However, these measures seem to be insufficient.

This study is a first approach to the reclamation of areas colonised by dwarf pine. This approach considers the hypothetical possibility of woodchip production. The felling of areas along the roadside seems to be the first priority for intervention. This approach will serve to maintain the forest road network in good condition, and this network represents the access point for all other reclamation interventions that could be planned to provide positive benefits resulting from exploitation by tourism and from enhanced aesthetic value.

Maintenance of the kind considered in this study could be viewed as a starting point. These reclamation measures should be followed by additional removal operations inside the dwarf pine stands or on the border between the pastures and the forest.

Network Analyst proved to be a valid tool to simulate the logistics of the operation, evaluate the transportation costs of the material and find the solution that minimised the total cost.

The output of the model can be used as a first estimate of the operational cost. The opportunity to improve the results using input data

(speed, loading/unloading time) derived from field data can also be considered in the future.

The analysis confirms that the operational costs are high, especially in light of the fact that work along the sides of the roads is the simplest situation. The removal of dwarf pine trees from the borders of pastures or the maintenance of suitable habitat for black grouse must be considered from a cost perspective. The operational costs of these interventions will increase in proportion to the distance from the road. A proposed solution to the problems raised by the economic constraints would be to find an alternative use of the material. However, the supply cost, ranging from 52 € t⁻¹ to 143 € t⁻¹, prevents the woodchips from being competitive on the wood fuels market. The projected production of 138 t y⁻¹ would appear to be too small for energy exploitation. The use of the material in the production of essential oils is an interesting possibility. This possibility is attractive in view of the high selling price of the product and the low quantities of material needed in the production process.

This hypothesis is supported by the experience of some areas in the South Tyrol region, where this system of production seems to work effectively and to yield economic, environmental and landscape benefits (BROLL and PIETROGIOVANNA, 2009).

The final step towards a solution to the problem of dwarf pine should be to activate a long-term management plan involving all the stakeholders (hunters' associations, farmers, tourism associations, historical associations, and wildlife ecologists) and considering all the economic and environmental consequences and opportunities associated with the current evolution of the landscapes.

RIASSUNTO

Una strategia per la gestione dei pascoli montani abbandonati e invasi dal pino mugo

L'espansione incontrollata di aree imboschite può costituire un problema di per sé. L'ampliarsi di queste aree può determinare la modificazione del paesaggio e della varietà degli habitat, l'attenuazione della bio- e dell'ecodiversità, l'omogeneizzazione del territorio accompagnata dalla perdita di risorse economiche e naturali. Nella parte

settentrionale dell'Altopiano dei Sette Comuni, un'area delle Prealpi venete, il Pino mugo (*Pinus mugo* Turra) è la specie arborea più invasiva e produce un elevato impatto sui pascoli alpini, sulle strade e i sentieri e sui siti storici della Prima Guerra Mondiale.

Lo studio considera i costi operativi per l'abbattimento dei fusti di Pino mugo, per il trasporto del materiale legnoso a specifiche aree di raccolta e per la sua cippatura in tali aree. Il problema logistico è stato approfonditamente analizzato utilizzando un sistema di supporto alle decisioni (DSS), basato su GIS e strutturato su un modello di analisi di reti, e ipotizzando differenti scenari associati a diverse condizioni della viabilità forestale. Si sono poi ricavati dei grafici del costo di approvvigionamento per analizzare il costo totale in funzione delle quantità di materiale ritraibili.

Lo studio pone in evidenza gli elevati costi per la raccolta che oscillano tra 52 € t⁻¹ e 143 € t⁻¹; essi diminuiscono, variando tra 52 € t⁻¹ e 107 € t⁻¹, solo intervenendo con opere di miglioramento della rete stradale.

Lo studio rileva come i sostegni finanziari previsti dall'Unione Europea così come dai governi nazionale e regionale non sembrino sufficienti per assicurare interventi adeguati a contrastare il fenomeno della diffusione del Pino mugo.

Vanno dunque considerati con attenzione possibili usi alternativi del materiale mediante processi a piccola scala (quali, ad esempio, l'estrazione degli oli essenziali) che possono agevolare il superamento delle barriere economiche.

REFERENCES

- BROLL M., PIETROGIOVANNA M., 2009 – *Pino mugo e mugolio. Tradizione e innovazione in Val Sarentino*. Sherwood, 15 (1): 45-48.
- CAVALLI R., GRIGOLATO S., 2010 – *Influence of characteristics and extension of a forest road network on the supply cost of forest woodchips*. Journal of Forest Research, 15 (3): 202-20. <http://dx.doi.org/10.1007/s10310-009-0170-4>
- CCNL, 2006 – *Contratto Collettivo Nazionale di Lavoro per gli addetti ai lavori di sistemazione idraulico-forestale e idraulico-agrari*.
- CONTI G., FAGARAZZI L. 2004 – *Sustainable Mountain Development and the key-issue of Abandonment of Marginal Rural Areas*. Rivista Planum, vol. XI: 1-20.
- COUNCIL OF THE EUROPE, 2000 – *European Landscape Convention*, Florence, 20 October 2000.
- DIRNBÖCK T., DULLINGER S., 2008 – *Organic matter accumulation following Pinus mugo Turra invasion into subalpine, non-forest vegetation*. Plant Ecology and Diversity, 1: 59-65.
- DULLINGER S., DIRNBÖCK T., GRABHERR G., 2003 – *Patterns of shrubs invasion into high mountain grasslands of the Northern Calcareous Alps (Austria)*. Arctic, Antarctic and Alpine Research, 35: 434-441.
- DYKSTRA D.P., 1984 – *Mathematical programming for natural resources management*. McGraw-Hill Book Company, New York, 388 p.
- ESRI, ARCGIS NETWORK ANALYST USER'S GUIDE: *ArcView® GIS Ver.9.3*, ESRI Inc., Redlands, California, USA - 2009.
- GLÄNZER U., 1985 – *Effects of land use changes on bird life*,

- example: Tetrao tetrix and Lagopus lagopus.* Transaction Congress International Union Game Biologist, 17: 501-507.
- LINDSTÖM J., RINTAMÄKI P.T., STORCH I., 1998 – *Black Grouse*. BWP Update 2: 173-191.
- MACDONALD D., CRABTREE J.R., WIESINGER G., DAX T., STAMOU N., FLEURY P., GUTIERREZ LAZPITA J., GIBON A., 2000 – *Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response*. Journal of Environmental Management, 59: 47-69. <http://dx.doi.org/10.1006/jema.1999.0335>
- MIYATA E.S., 1980 – *Determining fixed and operating costs of logging equipment*. St. Paul, MN: North Central Forest Experiment Station, Forest Service, USDA.
- NEGRIN M., PETTENELLA D., 2010 – *Produttività, convenienza economica e qualità. Indagine sull'approvvigionamento di cippato ad uso energetico*. Sherwood, 16 (4): 5-11.
- OSTERMANN O.P., 1998 – *The need for management of nature conservation sites designated under Natura 2000*. Journal of Applied Ecology, 35: 968-973. <http://dx.doi.org/10.1111/j.1365-2664.1998.tb00016.x>
- PORNARO C., SUSAN F., ZILLOTTO U., 2009 – *Effects of wood expansion on the specific biodiversity of mountain pastures*. Proceedings of the 15th European Grassland Federation Symposium. Brno, Czech Republic, 7-9 September 2009, p. 215-218.
- REGIONE DEL VENETO, 2006 – *Carta Regionale dei Tipi Forestali: documento base*. Regione del Veneto, Direzione Regionale per le Foreste e l'Economia Montana, Mestre (VE).
- SLATS P., BHOLA B., EVERS J., DIJKHUIZEN G., 1995 – *Logistic chain modeling*. European Journal of Operational Research, 87 (1): 1-20. [http://dx.doi.org/10.1016/0377-2217\(94\)00354-F](http://dx.doi.org/10.1016/0377-2217(94)00354-F)
- TALLOWIN J.R.B., ROOK A.J., RUTTER S.M., 2005 – *Impact of grazing management on biodiversity of grasslands*. Animal Science, 81: 193-198.
- WATKINSON A.R., ORMEROD S.J., 2001 – *Grasslands, grazing and biodiversity: editors introduction*. Journal of Applied Ecology, 38: 233-237. <http://dx.doi.org/10.1079/ASC.50780193>
- ZBINDEN N., SALVIONI M., STANGA P., 2003 – *La situazione del Fagiano di monte (Tetrao tetrix) nel Cantone Ticino alla fine del XX secolo*. In: AA.VV., 2004 - Atti del Convegno "Miglioramenti ambientali a fini faunistici: esperienze dell'arco alpino a confronto", San Michele all'Adige, Trento, 5 giugno 2003. 100 p. In: Sherwood 96, Supplemento 2.
- ZEITLER A., 2003 – *Maintaining Black Grouse wintering habitats by Alpine pastures management plans*. Sylva, 39: 97-102.
- ZOVI D., 2009 – *I boschi dell'Altopiano*. In: "L'Altopiano dei Sette Comuni", p. 210-252.