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Steering the impacts of ungulates on temperate forests

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Abstract

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Key words: Forestry, ungulate ecology, game damage, wildlife management.

Introduction

Damage to growing forest stock, often seen as a “game damage problem”, is part of a larger landscape-forest-ungulate problem that is increasing in many European and some American countries (Eiberle 1982; Crawford 1984; Gossow 1986; Gill 1992; Kuiters et al. 1996). For instance in Austria, game damage by roe deer (Capreolus capreolus), red deer (Cervus elaphus), and chamois (Rupicapra rupicapra) is a major problem in forestry, affecting up to one third of the forested area each year. Damage estimates are at least EUR 220 million/year for 10,000 km² of forest damaged (Reimoser 1998).

Relationships between levels of hunting pressure, deer densities and ungulate damage in forests have often been discussed in the literature (e.g. Mayer & Ott 1991; Ammer 1996; Rooney 2001). However, the effect on ungulate damage of different landscape conditions and forestry practices have been considered less (Bunnell & Eastman 1976). Long-term studies related to this, such as those of Gill et al. (1996), are rare.

In many countries, the traditional disconnection of forestry (the forest seen only as a plant community) and game management has been, and still is, a powerful source of conflicts between foresters and hunters (Otto 1979; Donaubauer 1994). The disconnection results from separate forestry and hunting laws and even separate education and training for persons concerned with the plant or animal components of the forest ecosystem. Except in national park management, there is no tradition that connects the two interest groups. Without each side having proper information concerning the problems and possibilities of the other, antagonism instead of synergism is often cultivated.

Thus, the forest-ungulate problem has ecological, economic and sociocultural dimensions. In this paper,
the problem in its complexity is described and a possible counteracting strategy is suggested. Only wild ungulates (herbivores) are considered; domestic ungulates in forests are not included.

Two main questions underlie the paper:

(i) Forest regeneration is naturally accompanied by wildlife impacts, especially browsing by wild ungulates, and many of the potential effects of ungulates on forest vegetation are already well known. How can these effects be managed to promote benefits and limit damage in relation to forestry, hunting and nature conservation?

(ii) Regrettably, foresters have long been, and often still are, of the opinion that the forest-game problems are primarily a matter of game-density reduction: the fewer the ungulates the lower the damage. Yet often, where hunting efforts and culling have been intensified, the reduction in game damage has not turned out to be as hoped (Gossow 1986). Large area investigations show (Völk 1998) that the impact of deer and the dimension of damage are mainly correlated with the damage susceptibility of forests, while the population density of deer plays a minor role. Such findings lead to the question: How can the impact of a given ungulate population on vegetation be steered by managing the forest and landscape type and structure, using what is known about habitat-ungulate interactions?

**Damage and benefit by ungulates**

Ungulates can have both damaging and beneficial impacts on forests (Putman 1986, 1996; Reimoser 1986; Fuller & Gill 2001), but an objective assessment of these impacts is difficult. When do ungulate impacts on a forest become damage? Not every twig browsed is damage to a tree; not every tree damaged is damage to a stand. Hasty and false inferences about damage frequently result in conflicts between foresters, landowners, hunters, nature conservationists, federal authorities, and even tourism interests. Especially from the viewpoint of nature conservation, determination of target or threshold values for objective damage assessment (e.g. density and species targeted for forest regeneration) is particularly difficult.

Ungulates can impact forest vegetation by trampling (including pawing and scraping), fraying, bark-peeling and, perhaps most importantly, browsing (both visible browsing and unseen browsing, such as feeding on seeds and seedlings). Intense selective browsing of certain tree species often results in reduced regeneration of these species, thereby changing the overall tree species composition (Mayer & Ott 1991). However, such impacts do not automatically mean damage to the forest. Damage in forestry terms may arise if the ungulate impact leads to a reduction in forest growth, economic value, ecological stability, species diversity, or in a forest’s protective function (e.g. against avalanches, land-slides, erosion, floods). Beneficial effects can result from increasing diversity and improved economic value by ungulates selectively browsing unwanted plant species and by improving germination conditions (seed dispersal, impact of hooves, and droppings); cf. Putman (1986, 1996), Howe & Westley (1988), Wolf (1988), Gill & Beardall (2001).

The concept of “damage” and “benefit” depends on resource targets set by different interest groups. The many land users with different objectives for the same land area (e.g. foresters, hunters, farmers, tourists and conservationists) add to the forest-ungulate problem. Thus, the core of the problem is not “conflict” between forests and wildlife, but between differing human interests (Gossow & Reimoser 1985). Conflicts are most evident in forested areas used for production of timber and other products, and are less evident in conservation areas that lack consumptive use of natural resources.

In general, the wildlife-ungulate problem in cultivated landscapes comprises two main aspects: damage to forest regeneration by wild ungulates and harm to ungulate populations and their habitats by human activities.

**Roots of the game-damage problem**

In this paper, the forest-ungulate problem is considered as operating on two scales: the whole landscape and the forest area alone. Recent decades have brought increasing reports of game damage generally, though differing in extent from region to region. Such reporting must, however, be carefully analysed. For example, if in a given area game damage is recognised for the first time or as occurring more intensely, the reason for the change must be determined (Figure 1). It often happens that an apparent increase is due to a change in monitoring methods and damage assessment, i.e. new data are not comparable with the old. Such changes may result when interest in one or more uses of the forest increases, or from a greater consciousness of game damage and introduction of more stringent criteria.

If the increase in damage is genuine, i.e. there is a real increase in browsing, fraying or peeling pressure, this can derive from (a) an increased need of game to engage in damaging activities, with no increase in game numbers, (b) a real increase in the numbers of game, and/or (c) a change in forest structure resulting in increased vulnerability of the forest itself to damage (Figure 1). Situation (a) can arise for several reasons: firstly because of a shortage of essential or appropriate
food, a shortage of water, digestion problems due to incorrectly fertilised pasture, or poor supplemental feeding practices; secondly, because of an increase in the level of disturbance, typically from increased human activity such as tourism or hunting – these resulting in an increased energy demand and, hence, a greater food demand. Both these situations can result in disturbance of feeding rhythms and/or of the rumen activity, i.e. the digestive process (Onderscheka 1985). Thirdly, there might be new stimuli that also increase damage predisposition. For example trees from a nursery are particularly prone to browsing damage.

In relation to (b), increasing ungulate density may arise: because the biotope is highly attractive to game (not only a reflection of better supply of food); because game remains in the biotope for longer periods than would normally be the case (e.g. curtailed seasonal migration to traditional overwintering areas as a result of building and infrastructure development); because rates of reproduction are higher; or because mortality has decreased (improved survival caused by lower selective pressure on game, though this is not necessarily an indication of a better quality of life for the animals).

The improved survival derives from the specific features of a cultivated landscape, e.g. an absence of large predators and advantageous biotope changes resulting from agricultural and forestry measures, as well as from game management aspects such as supplemental winter feeding and inefficient compensatory culling for this feeding.

Regarding (c), a forest's intrinsic disposition to game damage depends on both (i) the distribution of forest in the landscape, and (ii) the structure of the forest itself (Figure 1). In relation to (i), the damage predisposition is higher the lower the total area of forest and the more fragmented the forest area. Small areas of forest within agricultural land suffer large concentrations of ungulates, and hence greater browsing damage, when there is marked disturbance in the surrounding open areas or at certain seasons, typically in winter. In relation to (ii), three main factors increase the damage predisposition: sparse forest regeneration; strong habitat attractiveness with little food supply; and premature forest death. For example, following clear-cutting, areas with sparse reafforestation with new plantings (only some thousands of saplings per hectare as

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**Figure 1.** The main roots of game damage to forests on two scales: landscape (L) and forest (F).
compared with natural regeneration having as many as several hundred thousand seedlings and saplings per hectare) are particularly prone to game damage (Reimoser & Gossow 1996).

All the factors shown in Figure 1 must be considered when studying the interactions between ungulates and forest, and which, when out of balance, lead to unacceptable levels of game damage.

**Elements of a holistic solution**

There are three main goals in minimising forest–ungulate conflicts: (a) minimising conflicts between different interest groups, i.e. stakeholders; (b) protecting biodiversity and related natural ecological interactions; and (c) protecting economic values by seeking sustainable use of plant and wildlife resources.

Putman (1996) explained his reservations about damage limitation policies based entirely on population control. He proposed a policy of integrated management, combining efforts at population limitation with other measures, but emphasised that further work is required on all the factors predisposing a forest to severe damage. Kuiters et al. (1996) pointed out that the ungulate impact on forest development and its dependence on spatial and temporal patterns of forest regeneration is still poorly understood, making it difficult to control ungulate herbivory in commercial and conservation forests by habitat manipulation alone. Gossow & Reimoser (1985) and Völk (1998) showed that damage levels experienced initially may be a function of forest design, and that alterations to forest management and culture methods may be used as a tool to reduce existing damage levels.

Clearly, the balance in many forest ecosystems between animals, plants and the demands of humans is seriously disturbed. How can this be corrected? Artificial systems such as cultivated landscapes must be managed if they are to suit the diverse needs and wishes of humans. Consequently, there is a need for a more conscious and active integration of wildlife species into cultivated landscapes, providing proper biotopes for plants and animals and thereby reducing damage. As part of this, natural interactions should be better utilised to achieve sustained regulation.

One can consider wildlife management as a system comprising habitat, wildlife and damage-tolerance factors (Figure 2). These components require adjustment if a society’s demands and needs are to be met. Human impact in terms of silvicultural management has a profound and direct influence on two of these components – habitat (attraction for wildlife, susceptibility to damage, conditions for hunting) and damage-tolerance level (related to vegetation). Direct human impact on the wildlife component results primarily from hunting and different kinds of anthropogenic disturbance to animal populations.

The principles of a proposed integration strategy to manage for an acceptable (tolerable) level of ungulate damage require: definition of land-use aims for various areas; co-ordination of habitat and ungulate management (regarding composition, area, and seasonality); inclusion of game as a site factor in land-use planning; and the planning of hunting programmes, ensuring that the local vegetation has the capacity to support the intended game density with tolerable impact. Key actions required to support such a strategy are outlined below.

**Promote a flexible, integrated pattern of wildlife and forest management**

Forest managers must recognise that forest management is also habitat management, and that a near to

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**Figure 2.** Wildlife management. The human dimension within which wildlife management is undertaken comprises three interconnecting components, and proper wildlife management depends on harmonisation of all three. If one of the three components is altered, the others will tend to react, and may in turn have to be appropriately adjusted to maintain the desired balance.
natural interplay between these is necessary for better “coexistence” between ungulates and forests. Forestry must rehabilitate monocultural forests to be more natural. Clear cutting and artificial reforestation should be avoided, thereby reducing the predisposition of a forest to game damage (Otto 1979; Reimoser & Gossow 1996). It has been shown that such forest management (shelterwood felling, group and single tree selection, natural regeneration) is economically viable, indeed often more profitable than clear-cut management (Reininger 1987), while also providing an optimal forest environment that satisfies the local needs – for hunting, public use and tourism.

Wildlife-damage prophylaxis should be considered and integrated more systematically into the planning and practice of forest operations. In addition to the careful choice of the silvicultural system (as mentioned above), the following aspects should especially be taken into account (for details see Reimoser & Gossow 1996).

Choice of tree species (mixing ratio): It is important to achieve a proper balance between deciduous and winter-green tree species. If there are only winter-green species such as spruce and fir, which provide only a poor food supply in the dark stands though excellent thermal and hiding cover, the ratio of settling stimulus to available food is out of balance and the predisposition of the forest to game damage is increased, i.e. game damage is provoked.

Forest tending: Thinning of thickets and pole stands allows more light to reach the ground; the food supply increases, while thermal and hiding cover are reduced (Mayer 1977). Forest tending brings about a more balanced ratio between available food supply and the food-independent settling stimulus, and hence the forest’s disposition to suffer game damage is reduced.

Stand edges: Sharp, visually striking stand edges, the “edge effect”, should where possible be avoided to reduce game damage. In the case of roe deer, which typically frequents hedgerows and forest stand edges, it became clear that the visual separation of biotope types (not the overlapping as postulated by Leopold, 1933) was important for habitat attractiveness and settling stimulus (Reimoser & Ellenberg 1999). Roe deer did not feel at ease in forests with irregular, diffuse, eye-level vegetation, even where such areas offered the most varied and best supply of food. They preferred zones close to “optically” striking edges. When different biotope types bounded by sharp edges were in close proximity, this unnatural, over-attractive habitat provoked deer over-abundance and, hence, game damage.

Changing forestry practices to be “closer to nature”: In some European countries there is an increasing public demand that forests be restructured towards more “natural” ecosystems (Führer & Nopp 2001). This is matched by an obvious readiness to do so on the part of many foresters. To ensure tolerable levels of game damage, such “rebuilding” requires careful planning. A forest plantation often starts with reforestation of a clearcut or an afforestation of an abandoned meadow. Thus there is no pioneering phase with its typical initial succession of brush and non-timber trees, herbs and perennials – a type of vegetation that offers a very suitable food base for ungulates and serves as a helpful buffer against deleterious browsing of timber-tree saplings growing in the wake of this succession. In this connection, old tree stands should be supported as a source of food for game herbivores, especially by upgrading the understorey and ground-vegetation layers through improved and better directed thinning and clearing operations.

In general, a selective silviculture system favours balanced, healthy interactions between forestry, wildlife and hunting; clear-cutting and reforestation makes a forest attractive to many ungulate species and easy to hunt in, but susceptible to game damage (Partl et al. 2002). However, if game damage to the forest is not important and the aim is to have high ungulate populations, forest management with many strip clear-cuts could be very appropriate. For example, landowners are more tolerant of browsing or bark-peeling if income from hunting is the management priority and timber profits are low.

Create objective measures for game-damage assessment

Objective methods for assessing game damage control have to be developed, including systematic establishment of control exclosures (fenced control areas). Survey methods should be based on operational indicators of forest structures, with threshold values to evaluate ungulate impacts. These indicators should allow an objective monitoring of benefit and damage from ungulates on forest regeneration (Schulze 1998; Reimoser et al. 1999).

A case study: The relationship between benefit from and damage by ungulate game on natural forest regeneration was studied in two Austrian regions having roe deer, red deer and chamois populations (Reimoser & Reimoser 1997). Both regions were dominated by montane mixed forest (management aims particularly for spruce, fir, beech, and maple). The survey method (fenced control vs. unfenced areas) and the analytical method (current status/target stock comparison; Reimoser et al. 1997) were the same for both regions. Indicators, target values, and tolerance limits are shown in Table 1. About 800 test areas were studied over a period of six years. In both studies there
were areas in which the indicators exclusively showed game damage, and others with exclusive benefit, though the ratio of damage to benefit ranged from about 4:1 to 14:1. Whether the ungulate game impact – based on the test criteria (Table 1) – resulted in net benefit or net damage reflected also, in addition to targets and ungulate population, the predisposition for damage or benefit of the forest regeneration itself. This predisposition is markedly affected by forestry management practices. Both forestry and ungulate-game management must be deliberately targeted to obtain the most positive interaction between game and habitat structure.

At the same time, an objective control system for assessing ungulate populations might also be needed when animals listed as shot by hunters have not in fact been culled. This is a problem in some European countries with district-hunting systems. Hunters often want higher ungulate densities than allowed by state authorities, so they kill less than the minimum number demanded, reporting higher culling levels to satisfy the authorities (Donaubauer 1994).

**Optimise hunting strategies**

The many different hunting techniques, such as stalking, waiting in a hide or battue, and hunting strategies such as interval hunting and focus hunting (Reimoser 1991), are in practice mostly not optimised yet. Optimising culling without exerting undue hunting pressure is necessary for less shy game. This would result in a better game distribution, less game damage, easier culling, and less shyness vis-à-vis tourists (e.g. Hamr 1988; Petrak 1996). More detailed research is needed to develop optimum hunting strategies, and to clarify how problems resulting from hunting and tourism can be avoided.

**Game management in winter**

In some countries supplementary feeding of wild ungulates results in game markedly changing their avoidance and habitat-use strategies. Such feeding, which serves as an overwintering strategy, is an important steering instrument, for instance in alpine red-deer management, but it is not equally effective everywhere and at all times (e.g. Schmidt 1993). Winter feeding can increase as well as decrease game damage. Provision of such feeding sites has often been found to be counter-productive if judged by its effectiveness in preventing browsing and bark-peeling (e.g. Bubenik 1984; Gossow 1987). Key problems are incorrect application, and the need to increase the annual cull, an aspect usually forgotten. A possible management tool

Table 1. Indicators with operational targets and intolerance limits used in the monitoring system of the Austrian province Vorarlberg until 1991 (Reimoser et al. 1997). The limits for height increment loss (H) for slow growing (maximum annual growth <10 cm) and for rapidly growing regeneration were a loss of two and a loss of three height classes, respectively (out of eight). Multiple top twig browsing was used as an auxiliary (i.e. early warning) indicator for height increment loss. Shrub growth was also taken into account in some forest communities in which shrubs play a vital role with respect to preserving the productive power of the soil. Damage is taken to exist when any one indicator (a target value or a tolerance limit) is exceeded due to ungulate-game impact (comparison between fenced control and unfenced areas). Benefit exists when at least one indicator is achieved due to ungulate-game impact, e.g. one key tree species achieves a height increment gain of more than two height classes (or three for rapidly growing species), for example by browsing of competing tree species.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Target value(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Regeneration density</td>
</tr>
<tr>
<td>C</td>
<td>Composition type (deciduous, coniferous, mixed)</td>
</tr>
<tr>
<td>K</td>
<td>Key tree species</td>
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<tr>
<td>T</td>
<td>Tree-species number</td>
</tr>
<tr>
<td>I</td>
<td>Shrub-volume index(^b)</td>
</tr>
<tr>
<td>H</td>
<td>Height increment(^c)</td>
</tr>
<tr>
<td>S</td>
<td>Shrub-species number(^b)</td>
</tr>
<tr>
<td>B</td>
<td>Index of top-twig browsing(^e)</td>
</tr>
</tbody>
</table>

\(^a\): depending on anticipated natural forest community and forest function  
\(^b\): some forest communities  
\(^c\): highest trees of regeneration  
\(^d\): depending on maximum top-twig length  
\(^e\): top-twig browsing on highest trees during a period of 3 years
for red deer is to provide fenced winter enclosures around a feeding station (about 10 to 50 ha enclosures with 30 to 150 head of deer, respectively). This is a kind of “makeshift”, non-ecological solution which, nevertheless, eliminates game damage outside the enclosure during winter and spring, as well as disturbance by tourism inside (Reimoser & Onderscheka 1987). Limited use of this mechanism might be tolerable in heavily cultivated landscapes. It is, however, much better to provide safe, ecologically sound winter habitats.

**Establish protected areas**

Improved public access to forests, together with the continuing development of tourism and greater hunting pressure, have greatly increased human disturbance of wildlife. This has resulted in growing calls for zones protected against man’s intrusion for wildlife-habitat conservation and reduction of game damage (Gossow 1992). Nowadays tourists show a greater readiness to accept the need for wildlife protection and some related rules, e.g. keeping strictly to paths in conservation areas.

**Nature conservation and national parks**

To define “damage” in relation to nature conservation aims and targets requires definition of nature conservation values. Hence it is necessary to define what constitutes a favourable conservation condition. A favourable condition of a habitat has been defined as occurring when “the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue for the foreseeable future and the conservation status of its typical species is also favourable” (UK Monitoring Network and NATURA 2000 Coordinators Group 1997, unpublished). Damage would then be any change which induces a condition that can no longer be described as favourable.

If it is assumed that a decision has been made that a particular woodland type is to be conserved, how far can one go towards defining generic indicators of the condition of the habitat? To what extent are such indicators affected by the level of grazing and browsing by ungulates? Can it be assumed that, if the plant component can be “correctly” defined, that this will also “get the animal component right” (see Reimoser et al. 1999)?

Three different approaches towards tolerance of ungulate impacts on forest vegetation in national parks exist: (i) ungulate populations have priority, i.e. no shooting of ungulates inside the park; (ii) certain forest vegetation communities have priority, i.e. planned shooting of ungulates in the park; and (iii) ungulate populations and forest vegetation communities have equal importance, i.e. shooting of ungulates in the park depends on their exceeding the (defined) tolerance limits for browsing impact. A further aspect might also involve consideration of the park’s environs, i.e. to avoid undue game damage outside the park, culling inside it is allowed.

As one example, in Austria the type (iii) approach (importance of forest vegetation and ungulates equal) is applied in national parks (Reimoser 2001). Browsing tolerance limits inside the park are based on biodiversity, not on economic value. As a rule of thumb, the national park administration decided that up to 50% of a park’s forest area may be impacted by ungulates without restriction. This tolerance limit probably leads to an increasing biodiversity due to a wide range from heavily to little browsed plant communities. Monitoring systems with operational thresholds for browsing impact exist.

**Implement wildlife ecological spatial planning**

Forestry and hunting measures alone cannot solve the problem. They must be combined with measures that recognise the aims and targets of all stakeholders, including foresters, hunters, farmers, tourist authorities, with plans co-ordinated over landscapes large enough for sustainable management of the wildlife species of interest. A concept for large-area planning, with integrated management of ungulates and their habitats, has been implemented in some Austrian federal provinces and parts of Switzerland using an instrument known as WESP – Wildlife Ecological Spatial Planning (Reimoser 1996).

**Implementation problems**

The solutions considered above all derive from both wildlife biological research and applied research in forests and various landscapes. However, communication of results outside the community of wildlife and forestry researchers appears to be inadequate. In a study assessing how experts view wildlife damage control, implementation and research, 80% of respondents sought better communication of research results, as well as effective application of the findings (Reimoser & Völk 1990). Obstacles to the adoption of improved management practices reflect the complex nature of the problem, both biologically and socioeconomically.

Regarding future research priorities, all interested parties need to be included at the research planning and implementation stages to generate a sense of in-
volvement and ownership. The research requires interdisciplinary work in both the biological and social sciences, focusing on achieving programmes oriented towards sustainable management and the promotion of collaboration between stakeholders. Research priorities identified by Reimoser & Völk (1990) were: (i) long-term, large-area field research (interdisciplinary studies in different landscapes, model testing); (ii) establishment of practical methods to set output targets and measures, and to monitor browsing damage in relation to forest stands; (iii) tracing the historical development of forest damage by ungulates on which an understanding of the current situation can be based; (iv) incorporation of game-ecological factors into regional planning decisions (mechanisms, coordination, integrated management concepts, long-term follow-up); (v) complementary research into factors facilitating or hindering practical application of research findings (e.g. studies of laws and legal concepts, of political and administrative aspects, and of economic factors such as cost/benefit analyses of different management strategies; (vi) studies of ways to develop collaboration between the various stakeholders (forest managers, hunters, and representatives of local communities, tourist administrations and conservationists); (vii) synopsis of existing scientific results, regional differences in wildlife–forest interactions, and local experiences, supported by models or expert systems as initiated by Partl (2001).

Conclusions

To obtain an understanding of the forest–ungulate compartment within an ecosystem to promote better management, one must consider the impacts of ungulates on forest vegetation and, conversely, the impacts of habitat structure and dynamics on the ungulates. It needs to take into account the landscape structure and the forest’s predisposition to game damage.

The ungulate-forest-environment-human system is a many-faceted problem, needing flexible and integrative solutions involving all stakeholders. While initially, interactions between the system components need to be investigated individually to recognise the various impacts of the different factors involved, any ultimate solution must involve a synthesis that provides a holistic view, which must bring all system components into balance within the dynamics of the socioeconomic and ecological realities. This includes a definition of what is tolerable game damage to forest vegetation. In wildlife management, these realities require a coordinated legislative framework that promotes habitats for viable ungulate populations on a sustainable, long-term basis. In addition, these realities require thinking not only on a forest scale, but on a landscape scale, even transcending national boundaries.

In answer to the questions – How can the effects of ungulates on forests be managed? How can their impacts be steered? – it was pointed out above that there is already a body of knowledge that can indicate the ways in which landscape structures, forest stands and wild ungulates can be managed to achieve an optimum balance between the interests of the various stakeholders. However, every site has its own peculiarities, and researchers and the local interested parties must work together to develop a management plan that, when implemented, is regularly monitored. This will show whether theory fits the practice and whether some variables need to be adjusted to match the site-specific conditions. Such practical applications of research findings related to the forest-ungulate problem require that the researchers see stakeholders as equal partners, accepting their wishes regarding management targets and honouring their feedback about scientific results in respect of their spheres of interest. Furthermore, researchers must ensure that all results and suggested modifications to programmes are understood and “owned” by the various interested parties. To achieve success in such collaborative activities requires, too, that researchers learn to communicate effectively with those who not only have to understand and implement the results of their research, but who are the ultimate beneficiaries or losers as the management practices succeed or fail to meet the targets they set.

At the same time, biological and other research must be energetically continued to discover what additional interactions of importance exist that wildlife ecologists and other scientists have not yet sufficiently taken into account.

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