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REVIEW PAPER

Forest clumps: objectives, consequences, and suggestions for changes in the use of this type of retention forestry under conditions of small clearcuts

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ABSTRACT

Retention forestry, also known as green tree retention or variable retention is a silvicultural approach in which small patches of forest or individual trees are retained during harvesting. The most common form of retention forestry is leaving clumps of old trees and scattered individual trees in clearcuts, mimicking the natural dynamics of a disturbance such as windthrow or fire. The main purpose of such management is to maintain biodiversity, to provide dead wood, to improve soil conservation, and to diversify open clearcut areas. This article presents research findings on this topic, primarily highlighting the ecological benefits of retention forestry. The article also highlights the negative consequences, mainly economic, of leaving groups of mature trees on small clearcuts. In Poland, this practice mainly concerns pine stands, so the biotic and abiotic hazards associated with this group of tree species are highlighted. In some cases, these hazards can reduce the positive effect of tree groups related to biodiversity. Ways to change this practice that minimize the negative impacts of leaving groups of trees are suggested. From the standpoint of maintaining greater biodiversity, more attention should be paid to a proper selection of potential tree groups in the stand, with priority given to valuable admixture species, hollow trees, and trees with unusual shapes. To limit the risk of wind damage to remaining tree groups, they should be selected well in advance of felling and the slenderness index of trees should be lowered by thinning to make them more wind resistant. Given the small size of clearcuts in Poland, voluntary use of old-growth islands on clearcuts should be considered, especially in forests on former agricultural land and in locations that are conducive to wind damage. In small clearcuts, the function of a 'lifeboat' for plant, fungal, and animal species can be equally well-fulfilled by stands adjacent to the clearcut. One solution worth considering is leaving large fragments of intact stand at the scale of larger forest tracts.

KEY WORDS

tree aggregates, biodiversity, clearcutting, forest patches, green tree retention, silviculture

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Introduction

The idea of leaving trees and groups of trees on large-scale clearcuts originated in the 1980s in the Pacific region of North America (Washington, Oregon, and California in the U.S., and British Columbia in Canada, *e.g.*, Franklin, 1989; Franklin *et al.*, 1997; Lindenmeyer *et al.*, 2012) and spread to other regions of the world, including Europe, in subsequent years (Gustafsson *et al.*, 2012). The silvicultural system used to implement this idea is referred to as retention forestry, retention silviculture, or green tree retention. Elements of retention silviculture can also be used in management systems other than clearcutting, which mainly consist of leaving a larger number of old and dead trees than in normal practise (Gustafsson *et al.*, 2020a). However, the most common manifestation of retention forestry is leaving grouped and scattered individual trees on clearcut sites, also called 'clearcut with reserves'. The main objectives of this approach are to: (1) maintain ecological function (species refugia, provision of deadwood of coarse size, soil conservation) (*e.g.*, Franklin *et al.*, 1997; Luoma *et al.*, 2004; Gustafsson *et al.*, 2012, 2020a); (2) support silvicultural activities (natural regeneration) (Bernadzki, 1996); and (3) support an aesthetic function, *i.e.*, diversifying large, open forest areas and thus visually reducing the clearcut area, which increases public acceptance of clearcutting (Shelby *et al.*, 2005; McDermott *et al.*, 2010).

The first research on retention forestry began in boreal forests, and over the past 40 years an increasing number of publications each year have shown that it is of great scientific interest (Rosenvald and Lõhmus, 2008; Baker *et al.*, 2013; Fedrowitz *et al.*, 2014; Mori and Kitagawa, 2014; Gustafsson *et al.*, 2020b). At the same time, retention forestry is becoming more common in forestry practice. A compilation prepared by Gustafsson *et al.* (2012) shows that in the federal forests of Washington and Oregon (USA), where the average clearcut size is 40 ha, about 15% of the stand is left. In British Columbia, where the average clearcut size is about 30 ha, 62% of clearcuts in public forests have forest patches left up to 15% of the clearcut area. In the Canadian province of Quebec, the average clearcut area varies between 100 and 150 ha. There, up to 10% of the intact forest stand remains. At this scale, it is common to leave large portions of the stand intact, and the average area of a tree clump is 0.25 ha. Sweden, Finland, and Norway were the first countries in Europe to adopt retention forestry rules. In the 1980s and 1990s, these three countries introduced changes in forest management legislation and guidelines to integrate environmental considerations into harvesting activities (Gustafsson *et al.*, 2012). In Poland, leaving clumps on clearcuts, which predominantly occur in pine stands, has a formal tradition of about 30 years (Zarządzenie, 1995, 1999), but with respect to a specific category of protective forests (where protection is a primary function), some relevant recommendations were formulated much earlier. In the 4th edition of the Principles of Silviculture (Zasady hodowli lasu, 1979), Chapter VIII, 'Principles of Recreational Forest Management', it was recommended to 'leave individual trees or groups of trees to counteract the monotony of the landscape, and to leave hollow trees to create favourable conditions for birds and small mammals' (§ 38).

In Europe, where clearcuts are usually 2-4 hectares in size, it is not possible to leave large groups of trees; only very small groups or scattered individual trees are left, usually accounting for 3-5% of the clearcut area (or stand volume) (*e.g.*, Zasady hodowli lasu, 2012; Kuuluvainen *et al.*, 2019). Only in Estonia and Latvia is the threshold higher, up to 10% (Gustafsson *et al.*, 2012). The aim of this article is to discuss the advantages and disadvantages of leaving stand clumps on small clearcuts in temperate forests and to propose changes to this procedure for the conditions of Poland.

For the purpose of the article, a selection of articles from the Web of Science database was made, based on the keyword 'retention forestry'. Review articles (185 articles) were the principal sources, supported by selected primary literature cited in the reviews.

Scale of retention versus biodiversity

The main idea of retention forestry is to preserve refugia for rare plant and animal species (the stands left behind fulfil the so-called lifeboat function) that would not survive under conditions of a large open area with a different microclimate (Franklin, 1997; Uliczka and Angelstam, 2000; Mitchell and Beese, 2002; Heithecker and Halpern, 2007; Larrivée *et al.*, 2008; Baker *et al.*, 2013). At the same time, forest clumps allow these species to colonize adjacent areas (Sławski, 2006; Baker *et al.*, 2015; Loehle *et al.*, 2021), with the rate of dispersal influenced by factors such as time since clearcutting, habitat type, species composition of the clumps, and other factors (Tabor *et al.*, 2007; Halpern *et al.*, 2012; Baker *et al.*, 2013). Research by Sławski and Kowalczyk (2016) confirmed that even small clumps alter microclimatic conditions on a clearcut. This influence is pronounced even at clump sizes greater than 0.1 ha, although light and temperature conditions vary greatly within the clump, especially in the north-south direction. These conditions may favour species that tolerate shade well and are sensitive to large temperature fluctuations (Hannerz and Hånell, 1997). The response of specific groups of organisms to leaving intact stand fragments depends on both the species considered and the size and distribution of the clumps and trees left behind (Baker *et al.*, 2013; Johnson *et al.*, 2014; Mori and Kitagawa, 2014; Vanha-Majamaa *et al.*, 2017). In general, vascular plants with low dispersal ability and insufficient seed bank are thought to benefit the most from leaving clumps (Solarik *et al.*, 2010). However, if clumps are too small or there are few of them and the distance between them exceeds the dispersal capacity of a species with limited dispersal ability, their recolonization rate is likely to be low or non-existent. This may lead to their gradual extinction (Loehle *et al.*, 2021). Some species, such as herbaceous plants of later successional stages, may also take longer to return to pre-deforestation conditions: 60-90 years (Duffy and Meier, 1992) or even 100-150 years (Wyatt and Silman, 2010). From the standpoint of creating old-growth forest-like conditions in the remaining clumps, larger clumps are preferable, preferably large enough so that their interiors are not altered by the so-called edge effect. Loehle *et al.* (2021), who analysed the results of numerous studies on this topic, concluded that the more pronounced edge effect of smaller clumps significantly reduces their importance as habitat for herbaceous plants associated with old-growth forests. Some studies even suggest that leaving a few percent of old forests is not justified by ecological benefits (Fedrowitz *et al.*, 2014; Kuuluvainen *et al.*, 2019) and should not be considered an alternative to clearcutting, but a form of it. Studies conducted in Finland in recent years clearly indicate that leaving small clumps of trees, 0.01-0.09 ha in size, does not maintain the communities of bryophytes, deadwood species, and ground beetles present before clearcutting (Vanha-Majamaa and Jalonen, 2001; Koivula, 2002). In another experiment, Vanha-Majamaa *et al.* (2017) found no significant differences in understory vegetation effects between clearcutting and clearcutting with retention of 7% of the stand (average 51 trees per hectare) 10 years after harvest. Results from studies in North America and Fennoscandia have shown that even leaving 15-17% of trees and stand fragments is not sufficient to maintain the abundance and species diversity of understory vegetation in an existing stand (Craig and Macdonald, 2009; Halpern *et al.*, 2012; Johnson *et al.*, 2014).

The positive role of clumps in maintaining moss plant populations was demonstrated in a study by Hylander and Weibull (2012): 10 to 12 years after clearcutting, only 20% of the moss species present before clearcutting were still found in the cleared area, while 60% of the species were found in clumps. Rudolphi *et al.* (2014) showed that clearcut areas had only 10% of the moss plant populations present in the control stand, while clumps had 50%. Although large clearcuts are not a barrier to the spread of mosses and lichens by spores if they spread by propagules, their spread is significantly limited (Peck and McCune, 1997), and the success of recolonization may ultimately depend on appropriate stand characteristics (*i.e.*, tree composition and age) and microclimatic conditions (Loehle *et al.*, 2021). For animals, the impact of retention forestry also depends on the taxa and their mobility. Studies on soil fauna (springtails) (Sławska, 2000) showed that most of their species die in the smallest clumps, comparable to an open area of a clearcut. The author considered a clump area of 0.10-0.12 hectares optimal for this group of species. On the other hand, a study by Jasiński (2019) showed that both 0.06 ha clumps and 0.15 ha clumps do not maintain the ground beetle species typical of old stands. A study by Malmyszka and Skłodowski (2011) showed that the smallest size of a forest patch that ensures the establishment of stable carabid communities is 0.63 ha. In a Finnish study, spider communities changed less after logging in large patches than in small patches at paludified sites (Matveinen-Huju *et al.*, 2009).

A more comprehensive study in this area was conducted in 2015 by Baker *et al.* (2015). Their goal was to compare species diversity in the clumps and in the surrounding restored area and to see how these relationships evolve over time since clearcutting and for different groups of organisms. The study was conducted in a Douglas-fir forest complex in Washington State, USA, managed by logging 21-25 years ago and 5-8 years ago, where clumps were left. The size of the tree aggregates ranged from 0.4 to 1.3 ha. The similarity of plant and spider species composition between the clump and adjacent forest regeneration on the clearcut decreased significantly with distance from the clump, whereas it decreased only slightly for beetles. The mere fact that clumps were left, regardless of their size, affected the diversity of the groups of organisms studied, and in the case of plants, the age of the forest regeneration adjacent to the clump also played a role; in an older forest, the species composition of the plants was less different from the plants in the clump area than in a younger one.

A number of publications indicates that leaving old-growth clumps also has positive effects on other groups of organisms, for example, mycorrhizal fungi (Luoma *et al.*, 2004; Jones *et al.*, 2008; Outerbridge and Trofymow, 2009; Baker *et al.*, 2015). The influence of retained clumps on the movement of vertebrates, which are generally highly mobile, is related to factors such as microclimate, habitat characteristics, predation risk, and food base (Baker *et al.*, 2013). For example, the proportion of old, hollow trees in remaining clumps positively affects the presence of mammals associated with them, such as bats (Webala *et al.*, 2011) or flying squirrels (Selonen and Hanski, 2003).

Aubry *et al.* (2009), in a study conducted in Oregon and Washington, found no significant effect of remaining stock (15%, 40%, and 70%) on the three salamander species found there two years after clearcutting, although their abundance in the open area decreased significantly shortly after logging, which is confirmed by other studies on various amphibian species (Petranka *et al.*, 1993; Chan-McLeod and Moy, 2007). Amphibians prefer shady and moist places, thus, their abundance decreases with distance from the stand wall; their occurrence is also favoured by the presence of dead wood (deMaynadier and Hunter, 1999). Birds are among the organisms for which clearcuts are not an obstacle, but merely limit their ability to obtain suitable food. For example, leaving clumps on clearcuts reduces the abundance of birds associated with the open landscape (King and DeGraaf, 2000), but in general, studies indicate that bird abundance on clearcuts decreases significantly in the first few years after cutting, compared to clearcuts with leftover stand fragments (Otto and Roloff, 2012; Fedrowitz *et al.*, 2014; Venier *et al.*, 2015;

LaManna and Martin, 2017). Studies by Machar *et al.* (2019) showed that leaving old trees and clumps of trees on a clearcut in a temperate oak-dominated deciduous forest favours bird species diversity even approximately 20 years after logging; furthermore, bird species richness is actually higher in a diverse forest landscape shaped by retention forestry than in primary forests (Mori and Kitagawa, 2014).

Meta-analyses of the results of published studies provide the most comprehensive comparisons in this regard. Rosenwald and Lõhmus (2008) analysed the results of 214 studies from North America (81%) and Europe on the effects of green tree retention (GTR) on biodiversity. Compared to clearcutting, GTR reduced the loss of populations or individuals in 72% of the studies and almost always improved habitat for insects and birds after clearcutting. The type of trees left always contributed to the success of GTR, followed by tree density (65% of cases) and spatial distribution of trees (50%). Similar results emphasizing the positive effect of tree aggregates on biodiversity conservation were provided by the meta-analyses of Fedrowitz *et al.* (2014), which included about 900 publications comparing species richness of forest patches and clearcuts, and Mori and Kitagawa (2014), who compared retention forestry with primary forests in different regions of the world. Examples of the negative effects of the presence of groups of trees on different groups of organisms are few, with only photophilic grasses and herbaceous plants found to have a lower trend in the presence of trees (Hannerz and Hånell, 1997), along with some rodents (Sullivan and Sullivan, 1998), and the abundance of regeneration of pioneer tree species (Brais *et al.*, 2004).

Negative consequences of leaving aggregates

First of all, it is necessary to describe the extent of retention forestry practiced in Poland. Every year about 20% of harvested timber comes from clearcuts (Raport, 2020), which corresponds to about 7.5 million m^3 of timber. The maximum allowable clearcut area is 4 ha, but is usually smaller. The majority of forests managed in this way are Scots pine *Pinus sylvestris* L. forests, which is the predominant tree species in Polish forests (about 60% of the area) (Raport, 2020). According to forestry regulations (Zasady hodowli lasu, 2012; Rozporządzenie, 2017), clearcutting may leave a maximum of 5% of trees, with a minimum clump area of 6 ares. The potential ecological benefits of this practice have been described above, but it also has negative consequences that make some practitioners shy away from leaving tree aggregates. Because this practice primarily affects pine stands, biotic threats are associated with this particular species. Among the most serious pests associated with clumps is the steel blue jewel beetle *Phaenops cyanea* (F.), which causes significant tree mortality in the first few years after the clump establishment as a result of rapidly increased solar radiation (Sowińska *et al.*, 2020). Other species that pose a similar threat include the small pine shoot beetle *Tomicus minor* (Htg.), sharp-toothed bark beetle *Ips acuminatus* (Gyll.), pine weevil *Pissodes piniphilus* (Herbst), and six-toothed bark beetle *Ips sexdentatus* (Boern.). The greatest influence of the steel blue jewel beetle was observed in clumps up to 4 years after their establishment, and a similarly high tree mortality rate is observed in adjacent stand fragments exposed as a result of clear-cutting (Sowińska *et al.*, 2020). In some cases, this factor may reduce the positive effect of clumps in terms of biodiversity. As reported by Lõhmus and Lõhmus (2010), epiphyte communities associated with trees on clumps are threatened by the loss of trees in the years following logging.

Wind damage is another problem (Jönsson *et al.*, 2007; Rosenvald and Lõhmus, 2008). As expected, greater damage is observed in more fertile, moist habitats where trees develop shallow root systems. Bernadzki's (2002) study in old pine stands showed that the number of tree losses, mainly due to wind damage, was lowest in large groups of trees compared to smaller groups and individual trees. Losses are also caused by wood rot that progresses with age (Bernadzki, 2003). The analysis by Beese *et al.* (2019) also found that wind damage was much greater when individual trees and small groups were left compared to larger groups. Leaving overly large tree aggregates, in turn, negatively impacts young tree growth on clearcuts, primarily through shading and root competition (Bradshaw, 1992; Bolibok and Szeligowski, 2011; Baker *et al.*, 2013), although these effects are ambiguous and dependent on many factors. In general, the edges of clumps are shadier, moister, have lower air and soil temperatures, and are less susceptible to temperature extremes (*e.g.*, Heithecker and Halpern, 2007). The effect of clumps on young tree generation growing on the north side of the clump differs from that on the south side; it is greater on more fertile habitats than on dry and sandy soils, where shading may actually create more favourable moisture conditions for regeneration than the open area (Imurzyński, 1969). In addition, the negative effect of clumping can be offset by planting mixtures of shade-tolerant species in shaded areas. Cover of the remaining stand, on the other hand, may increase the likelihood that seedlings will be damaged by deer (Marcot and Meretsky, 1983; Bauhus *et al.*, 2009).

Under approximate assumptions, the economic consequences of leaving clumps on clearcuts can be calculated. Assuming that the above-mentioned 7.5 million m3 harvested in clearcutting represents about 95% of the wood that can be harvested in clearcutting, at least 397,000 m^3 of wood (5%) will remain on the clearcut area on an annual average, which, assuming an average raw material price of PLN 198.44 in 2020 (Leśnictwo, 2021), results in an amount of about PLN 78.8 million (about 17.1 million EUR). This is 1.04 percent of the LP's (State Forests) revenue from timber sales (Leśnictwo, 2021). In some countries (Germany, Finland) there are economic incentives in the form of subsidies for private forest owners as compensation for measures that increase the level of forest environmental protection, including for leaving tree clumps on clearcuts. Compensation may also consist of higher prices for certified timber and better access to markets where there is demand for responsibly produced forest products (Gustafsson *et al.*, 2012). With respect to state forests in Poland, from an economic perspective we can only talk about the costs associated with leaving clumps on clearcut areas.

Proposals for changing the practice of leaving tree clumps under conditions of small clearcuts

Considering all the advantages and disadvantages of leaving tree clumps on clearcuts, some measures can be proposed to increase their effectiveness in Polish forestry, *i.e.*, forestry with small clearcuts, and to reduce the negative impacts associated with them. First, from the point of view of preserving greater biodiversity under the conditions of clearcutting, it makes sense to leave those fragments of the stand intended for felling that stand out ecologically from the whole, those with slightly different, interesting microhabitats, and natural regeneration. In addition to valuable tree admixtures that are rare in the stand, preference should be given to long-lived tree species that serve the development of biodiversity over a longer period of time (Lõhmus *et al.*, 2006). Biodiversity conservation is enhanced by leaving economically unattractive trees in the forest, *i.e.*, those with unusual shapes, cavities, *etc.* (Kaila *et al.*, 1997; Martikainen, 2001; Junninen *et al.*, 2007). Their presence is determined by 'savings' in silvicultural treatments in younger-aged forests, which are usually removed first in silvicultural practice (Zasady hodowli lasu, 2012; Gustafsson *et al.*, 2020a).

Another aspect is the slenderness index of the trees left behind; the lower the index, the less likely the tree will be damaged by wind (Gil, 2006). The slenderness index can be shaped much earlier, as part of the thinning process before the clump is exposed, but this would require the site manager to identify potential sites in advance. An analysis by Bernadzki (2002) shows that the percentage of tree losses remaining in a clearcut increases with the crown factor of a pine stand prior to clearcutting. Given the small size of clearcuts in Poland and the increasing proportion of other types of logging, the voluntary use of tree clumps on clearcuts should be considered, especially in forests on former agricultural land and in locations susceptible to wind damage. In small clearcuts, the function of a 'lifeboat' for plant, fungal, and animal species can be performed equally well by stands adjacent to the clearcut or growing in close proximity. The death of trees in the zone adjacent to a logging area from sudden exposure and pest infestation may be an alternative for increasing the amount of deadwood. Perhaps the optimal solution in the context of forest conservation would be to consider the issue of leaving intact groups of trees on a larger scale, such as in a forest compartment (typical size ca. 25 ha) or whole forest tract. The role of such groups of trees could then be taken over by whole fragments of forest stands, not too large, that are left in the course of use. From the point of view of biodiversity, it would be best to leave such stands that stand out from the rest, as previously noted, or to protect nearby areas with suitable attributes. It seems important to leave stand fragments along watercourses instead of aggregates. Such buffer strips maintain species richness better than open, bare areas (Hylander and Weibull, 2012; Gustafsson *et al.*, 2020b).

Further research on this topic is also needed in our climate zone, e.g., on the effects on various types of organisms of the numbers, diversity, and sizes of trees left on clearcuts. Returning to two-generation management in pine stands, one of the older forms of forest management consistent with the idea of retention forestry, seems worth considering (Bernadzki, 1996; 2003). When deciding to leave clumps of old-growth stands and individual trees in clearcuts, more attention should be paid to the proper selection of trees, while accounting for – in addition to the ecological benefits of such management – the possible economic benefits in the future. In such a stand, it will be possible in the second generation to start the process of leaving the clumps from the beginning, or to leave the existing ones to decay naturally. Finally, special consideration is appropriate for forests close to cities, where, apparently, clumps have the greatest justification, because according to the Principles of Silviculture (Zasady hodowli lasu, 1979) they can counteract the 'monotony of the landscape'. When the forest manager cannot do without clear-cutting in such places (for habitat and stand reasons), leaving clumps is reasonable, but at an appropriate distance from hiking trails.

Conflicts of interest

The author declare the absence of potential conflicts of interest.

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STRESZCZENIE

Kępy starodrzewu – cele, konsekwencje i sugestie zmian w stosowaniu tej formy leśnictwa retencyjnego w warunkach niewielkich zrębów

Celem artykułu jest omówienie zalet i wad kęp drzewostanu pozostawianych na niewielkich zrębach zupełnych wykonywanych w lasach strefy umiarkowanej.

Idea pozostawiania drzew i grup drzew na rozległych zrębach powstała w latach 80. XX wieku w Ameryce Północnej i dotarła w inne regiony świata w ciągu kolejnych kilkunastu lat, w tym również do Europy. System hodowli lasu, który zaimplementował tę ideę, nazywany jest leśnictwem retencyjnym (retention forestry). W Polsce najczęstszą jego formą jest pozostawianie na zrębach kęp starodrzewu i pojedynczych drzew. Ich zadaniem jest dostarczanie martwego drewna, ochrona gleby, zwiększanie bioróżnorodności oraz pełnienie roli estetycznej poprzez optyczne urozmaicenie dużej, otwartej powierzchni zrębu. Pozostawianie kęp na zrębach, wykonanych głównie w drzewostanach sosnowych, ma w Polsce od strony formalnej około 30-letnią tradycję (Zarządzenie 11 1995; Zarządzenie 11a 1999), chociaż w odniesieniu do specyficznej grupy

lasów ochronnych zalecenia w tym zakresie były sformułowane znacznie wcześniej: w IV edycji Zasad hodowli lasu (1979).

Zachowane fragmenty drzewostanu na zrębach, zwłaszcza o dużej, nawet kilkudziesięciohektarowej powierzchni, mają istotne znaczenie dla różnorodności gatunkowej większości grup organizmów, zwłaszcza tych mniej mobilnych (mszaki, porosty, rośliny i bezkręgowce), co potwierdzają liczne badania prowadzone w różnych regionach świata.

W warunkach europejskich, gdzie zręby są najczęściej 2-4-hektarowe, pozostawiane małe grupy drzew lub ich pojedyncze egzemplarze obejmują najczęściej 3-5% powierzchni zrębu (lub miąższości użytkowanego drzewostanu). Niektóre badania sugerują jednak, że taka wielkość nie ma uzasadnienia w postaci korzyści ekologicznych. Pozostawianie kęp starodrzewu na niewielkich zrębach ma również negatywne konsekwencje, w tym ekonomiczne. Nie bez znaczenia jest też duża śmiertelność pozostawianych drzew w wyniku szkód od wiatru i zagrożenia ze strony szkodliwych owadów związanych z drzewostanami sosnowymi, jak również negatywne oddziaływanie na wzrost odnowienia na przylegającym zrębie. Aby zminimalizować wady tej formy zagospodarowania, w artykule przedstawiono propozycje jej modyfikacji. Z punktu widzenia zachowania większej bioróżnorodności w warunkach gospodarki zrębowej warto pozostawić te fragmenty drzewostanu planowanego do wyrębu, które wyróżniają się pod względem ekologicznym na tle całości – nieco innymi, ciekawymi mikrosiedliskami czy występowaniem odnowienia naturalnego. Oprócz cennych domieszek, rzadkich w drzewostanie, do pozostawienia na zrębie powinny być typowane długowieczne gatunki drzew, które będą długo służyły rozwojowi bioróżnorodności, oraz drzewa zahubione i dziuplaste, nieatrakcyjne z gospodarczego punktu widzenia. W celu ograniczenia szkód od wiatru wskazany byłby wybór potencjalnych kęp i kształtowanie wskaźnika smukłości wybranych drzew w ramach trzebieży na długo przed rozpoczęciem cięć rębnych.

Mając na uwadze zarówno niewielki rozmiar zrębów w warunkach Polski, jak i rosnący udział innych rodzajów rębni, należy rozważyć dobrowolność stosowania kęp starodrzewu na zrębach zupełnych, zwłaszcza w lasach na gruntach porolnych oraz w lokalizacjach sprzyjających powstawaniu szkód od wiatru. Przy niewielkich powierzchniowo cięciach zupełnych funkcję „szalupy ratunkowej” dla gatunków roślin, grzybów i zwierząt równie dobrze może pełnić przylegający do zrębu drzewostan. Wartym rozważenia rozwiązaniem jest pozostawianie nienaruszonych fragmentów drzewostanu w większej skali, np. oddziału lub kompleksu leśnego. Pożądaną rolę ekologiczną mogłyby pełnić wówczas całe, niezbyt wielkie wydzielenia lub ich fragmenty pozostawione w toku użytkowania.