Conserving Biodiversity in Forest Bioenergy Production Systems

FACT SHEET 7.5

Biodiversity[1], or biological diversity, can be defined as the number and variety of plant and animal species, genes, ecosystems, and ecosystem functions in a specific area. Biodiversity encompasses diversity in habitat, species, and genetics. Habitat and habitat diversity are particularly important concepts for forest managers and owners to understand to maintain biological diversity in bioenergy production areas. Habitat[1] is defined as the natural environment of a plant or animal and is characterized by the quality and quantity of food, water, shelter, cover and space available to a particular species. Habitat diversity refers to the complexity, distribution, and abundance of different plant and animal habitats in a given area.

Forest managers who manage for bioenergy production systems will have a direct effect on habitat and habitat diversity. This is primarily due to manipulation of the vegetation, soil, water, and temperature of a given site. Potential bioenergy-related activities can decrease the quantity and quality of habitat avalable at both stand and landscape levels. Activities include harvesting of trees and deadwood for energy feedstock, increasing road networks to access previously unmerchantable fiber, more frequent interventions into the forest (especially during times of the year when wildlife are most vulnerable, e.g. breeding, nesting and calving seasons), land use changes and inadequate provision of protected areas. Foresters and landowners must be aware of the effects of bioenergy production on biodiversity, and ways any negative impacts can be mitigated or minimized. Table 1 provides a concise summary of the potential effects of bioenergy production on forest biodiversity.

Ensuring adequate habitat area and connectivity throughout forested landscapes is one way to mitigate against extinction and cultivate biological diversity. Species requirements for habitat vary in terms of scale and their specific demand for food, shelter and reproduction over time. Managers must consider the relative value of a large number of individual habitat areas versus a single large habitat area. Both may be necessary to conserve biodiversity across a number of species. However small the habitat requirements of a species, small habitat areas can lead to problems such as inbreeding depression, overpopulation, and overuse of the habitat area. These same problems can be created if the distance between areas is too large and the terrain is too rough. Species must be able to freely move from one habitat area to another. Vegetation quality and water quality are also important for biodiversity. Habitat area, connectivity and forest cover type, along with other factors that affect the amount of food and shelter available, affect the quality of habitat available for species.

Several conservation techniques and perspectives can maintain biodiversity across forests managed for bioenergy. These include

Mayfield, C.; C. Smith; B. Lattimore. 2007. Conserving Biodiversity in Forest Bioenergy Production Systems. Pages 261–266.
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Aspect	Potential Issues	Contributing Activity	Examples of Mitigating Practices
Landscapes and ecosystems	Decrease in habitat characteristics and diversity at landscape levels Decrease in overall forest health → increased susceptibility to insects and disease Decrease in habitat connectivity at both the landscape and stand levels (e.g., forest patches, migration corridors, connected networks of downed woody debris) Inadequate protected areas Land use/ecosystem changes Reduction in ecosystem functions and services Off-site impacts of forest operations and plantations	Demand for energy feedstock → excessive deforestation Multiple interventions during the rotation → mechanical damage to residual trees Expanded road networks Unsustainable harvesting of dead and downed wood Design, location and effectiveness of protected areas Land use changes leading to loss of structurally diverse and productive ecosystems Afforestation of farmland	Use landscape analysis techniques to assess landscape-level features of the site (e.g., patch size and shape, connectivity) Ensure habitat quality and connectivity through: patch design; pay attention to species requirements; incorporate corridors Create buffer zones around habitats of threatened or endangered species
Habitats	Loss of downed woody debris and dead wood needed for the survival of some species of mosses, fungi, saproxylic insects, amphibians, small mammals and cavity nesting birds Overall reduction in area, diversity, and quality of forest and adjacent aquatic habitats	Increased thinning with removal Unsustainable downed woody debris removal Unsustainable biomass production systems and absence of appropriate management planning	Manage stands for structural diversity (e.g., structural retention at the time of harvest; long rotation periods) Create suitable habitat (e.g., nest boxes)
Species	Loss of forest cover and associated habitat Proliferation of invasive species and species that prefer disturbance landscapes Excessive disturbance of wildlife during critical seasons (e.g., breeding, nesting, calving) Species loss and inadequate maintenance of trophic levels	Encouragement of native or invasive weeds Unsustainable biomass production systems and absence of appropriate management planning New roads and increasing traffic into forests	Manage weeds appropriately Maintain adequate buffer zones for species requiring "interior" forest habitat
Genes	Maintenance of critical breeding populations of all organisms	Unsustainable biomass production systems and absence of appropriate management planning	Incorporate wildlife management guidelines into biomass production systems

Table 1. Potential Environmental Impacts of Bioenergy Harvesting on Forest Biodiversity

the **landscape perspective**, the **umbrella species concept**, and **manipulation of structural complexity** and **spatial configuration**. By using these techniques, forests can be managed for both biomass production and wildlife attributes.

Using the landscape perspective[1], forest managers get a complete picture of how a small stand fits into the larger landscape. This approach allows managers to evaluate the amount of habitat area over a larger area, rather than just one stand. This is extremely important for species requiring large habitat areas.

The umbrella species concept[1] allows forest managers to manage for one species, yet maintain habitat for several species. To use this technique, managers identify one species that has particular habitat requirements, and whose presence and population health is highly correlated with other species. By managing the habitat area for the target "umbrella species," managers can successfully maintain habitat for several species by association.

Biodiversity can also be maintained in managed forests by manipulating stand structure and spatial configuration[2]. There are three ways to manage stands for biodiversity: 1) structural retention at the time of regeneration harvest; 2) management for creation or maintenance of structural complexity; and 3) management for long rotation periods.

STRUCTURAL RETENTION

When harvesting biomass for bioenergy, retain suitable habitat areas such as large trees, snags, standing deadwood and downed woody debris (DWD) *(Image 1)*[2]. While some of this material may be attractive for bioenergy production, if your management goals include wildlife conservation, evaluate large, dead woody material for its value as habitat before harvest[1]. Generally, large trees and deadwood are important wildlife habitat and should be maintained. They are also the precursors of downed woody debris, a component of forest ecosystems necessary for the survival of many species of fungi, insects and small mammals. Retaining suitable amounts of these materials have additional benefits for soils and hydrology (see relevant fact sheets). However, evaluate each stand with landowner management objectives in mind.

MANAGING STANDS FOR STRUCTURAL COMPLEXITY AND BIODIVERSITY

There are several ways to manage stands while ensuring biodiversity. The first method is through thinning and harvesting to produce stands with a more complex structure, including mixed ages of trees, which favor biodiversity[2]. Small-diameter trees can be removed during biomass harvesting, decreasing competition for remaining trees and opening small gaps on the forest floor in which undergrowth can thrive. This can provide suitable habitat for birds and mammals that prefer low brush cover over standing timber. The second method is to create suitable habitat, such as installing nest boxes *(Image 2)* for red-cockaded woodpeckers. You can also create and maintain suitable habitat through the use of buffer zones[3]. Buffer zones along streamsides (streamside management zones) protect aquatic species while also maintaining water quality. Buffer zones can also be located along forest edge to protect terrestrial species. These zones are areas that are not harvested and generally placed near or between harvested areas. Native species, both plant and animal, can also be introduced into a stand to ensure biodiversity.

LONG ROTATIONS

Long rotations are another technique that can be used to create structurally complex stands[2]. Long rotations allow for the growth of old, large trees that are important species' habitat. Rotation length can be extended by 50 to 300 percent. While this is not an attractive option to many managers and landowners with goals of timber production or possibly biomass production, it can be useful in buffer zones not intended for harvesting. For individuals with specific management goals for wildlife conservation, long rotations may be of particular value.

CONCLUSIONS

Careful consideration of habitat conservation will ensure that species are maintained for future generations while providing raw materials to produce bioenergy and other bio-based products. In stands managed for bioenergy feedstock, habitat preservation may require special attention as biomass utilization has the potential to remove essential habitat. Evaluate stand structure and biomass availability during development of forest management plans, and by applying Adaptive Forest Management procedures. Assess the potential for harvesting operations to achieve such landowner objectives as production of bioenergy feedstock, timber, water, recreation, and wildlife habitat.

source: C. T. Smith, IEA Bioenergy Task 31

Image 1. Deadwood is important for maintaining habitat.

source: U. S. Fish and Wildlife Service

Image 2. Install sest boxes to create habitat.

ENDNOTES

1 Angelstam, P.; Mikusinski, G.; and Breuss, M. 2002. Biodiversity and forest habitats. In: Richardson, J.; Bjorheden, R.; Hakkila, P.; Lowe, A.T.; and Smith, C.T., eds. Bioenergy from Sustainable Forestry: Guiding Principles and Practice. Dordrecht, The Netherlands: Kluwer Academic Publishers: 216–243.

2 Lindenmayer, D.B.; Franklin, J.F. 2002. Conserving forest diversity: A comprehensive multiscaled approach. Washington: Island Press: 351 p.

3 Russell, K.R.; Wigley, T.B.; Baughman, W.M.; Hanlin, H.G.; and Ford, W.M. 2004. Responses of Southeastern amphibians and reptiles to forest management: A review. In: Rauscher, H.M. and Johnsen, K., ed. Southern Forest Science: Past, Present, and Future. GTR-SRS-75. Asheville, NC: USDA Forest Service Southern Research Station: 319–334.