Summary

Growth and death of branches largely determine the development of crown architecture, which in turn strongly affects not only growth and survival of trees, but also the structure, dynamics, and productivity of forest stands. Therefore, it is crucial to identify the factors controlling branch growth and death within tree crowns to construct reliable models for predicting the growth and development of trees as well as for providing useful guidance for forest management. Because of mutual-shading from neighboring individuals or self-shading within a tree crown, light intensity is commonly heterogeneous within a tree crown in a natural stand. Although light is known as an important factor affecting crown formation and development of various tree species, the role of light in the growth and survival of branches, especially at different levels of branching units, within a tree crown is still poorly understood.

In this study, I investigated the effects of light intensity and other morphological factors on the growth and death of branches and the growth of epicormic shoots in trees of a plantation of *Picea glehnii* (F. Schmidt) Mast. (Sakhalin spruce) in the Sapporo Experimental Forest of Hokkaido University, Sapporo, Hokkaido, Japan. In this study the branches forking from the main trunk were defined as primary branches, and those branching from a primary branch as secondary branches. An epicormic shoot is a shoot initiated from a bud that had been dormant underneath the bark of a branch. Local light intensity was represented by relative photosynthetic photon flux density (rPPFD) recorded above a branch.

Probability of death of a primary branch decreased as the length between its basal location and the crown base (L_{CB}) increased ($p<0.05$), but this probability was not significantly related to the relative photosynthetic photon flux density (rPPFD) above the primary branch ($p>0.05$). Probability of producing one or more current-year shoots on a primary branch increased with increasing rPPFD above the primary branch ($p<0.05$), while it was not significant for L_{CB} ($p>0.05$). Secondary branches at the distal part of a primary branch produced more current-year shoots and exhibited a lower probability of death than proximal branches ($p<0.05$), probably because rPPFD above the distal secondary branches was greater than at the proximal branches ($p<0.05$). Therefore, local light conditions are relevant to shoot production and shoot death on a primary branch, death of an entire primary branch may be related to some morphological attributes concerning the length to the crown base.

In addition, local light intensity had no significant effect on the number of current-year epicormic shoots on primary branches. Primary branches on shaded trees produced more current-year epicormic shoots than those on sunlit trees. Therefore, the production of epicormic shoots occurs in Sakhalin spruce as a normal and an integral part of crown architectural development, and is likely to be a component of a strategy that prolongs tree longevity, especially for those less vigorous Sakhalin spruce trees.

In conclusion, this study revealed that local light intensity alone cannot fully explain the growth and survival of branches, and growth of epicormic shoots is likely to be an adaptive growth strategy in the development of crown architecture to maintain crown productivity of Sakhalin spruce.