Summary

I attempt to determine how different aspects of plant function relating photosynthesis and water transport are coordinated developmentally for species with different vessel porosity and arrangements that coexist in the temperate zone. I observed the timing of leaf phenology and vessel formation in twigs and stems from an ecophysiological viewpoint, focusing on how vessel porosity and arrangements affect species' adaptation to their environment.

Chapter 1 reviews the previous studies of the association between leaf production and vessel formation, and describes the study sites and sample trees examined, and the methods for observation of leaf phenology.

Chapter 2 describes the increment borer method to trace the periodic process of vessel formation. The results suggest that the negative effect on trees caused by sampling is small, and vessel formation in sample trees is traced despite occasional separation of cambial zone from core samples. Based on a comparison of dying methods between double staining with safranine and fast green and the phloroglucinol-hydrochloric acid reaction, the former was considered applicable to investigate vessel formation, including the timing of vessel lignification.

In Chapter 3, by using the method of Chapter 2, I examined the temporal relationship between leaf phenology and vessel formation in twigs and stems for species of ring- and diffuse-porous deciduous tree species in a temperate forest. Ring-porous deciduous species form new wide twig and stem vessels concurrently with leaf appearance, because vessels of the pore-zone formed in the previous year have become dysfunctional. In contrast, diffuse-porous deciduous species can transport water in several rings, thus new twig vessels are formed at the time of leaf appearance, long before stem vessel lignification. Although phylogenetically distant, various ring-porous species showed the same tendency of leaf and vessel formation and, although phylogenetically distant, various diffuse-porous species showed the same tendency of leaf and vessel formation.

By using the sample trees of Chapter 3, I determined the temporal relationships between vessel formation and leaf phenology throughout the early stage to the later stage of annual ring formation in Chapter 4. I distinguished between flush leaves and successive leaves and three size

classes of vessels were measured. The results suggest that ring-porous species form leaves and vessels synchronously to accommodate water-transport requirements, whereas diffuse-porous species form these organs asynchronously; thus, unlike the latter, the former species change vessel diameters according to leaf formation.

In Chapter 5, phenological relationship between leaf appearance and twig and stem vessel formation was studied in evergreen and deciduous tree species with different porosity and vessel arrangement in a temperate forest. The difference was tested between the semi-ring-porous deciduous, ring-porous evergreen, diffuse-porous evergreen, or radial-porous evergreen species and the ring-porous deciduous or diffuse-porous deciduous species. These results may indicate a variation in phenology of organ development within each species. Ring-porous deciduous species show leaf and vessel production in shorter duration, compared to diffuse-porous deciduous and radial-porous evergreen species. In diffuse-porous evergreen species, a few individuals showed leaf and vessel production in short duration, while the majority of trees showed a production in long duration. Individuals within semi-ring-porous deciduous and ring-porous evergreen species showed characteristics similar to those of ring-porous or diffuse-porous deciduous species.

Chapter 6 determined how different aspects of plant function are coordinated developmentally for species with different porosity and vessel arrangement coexist throughout the temperate zone and attempted to clarify how porosity and vessel arrangement affects species' adaptation to their environment by determining this.