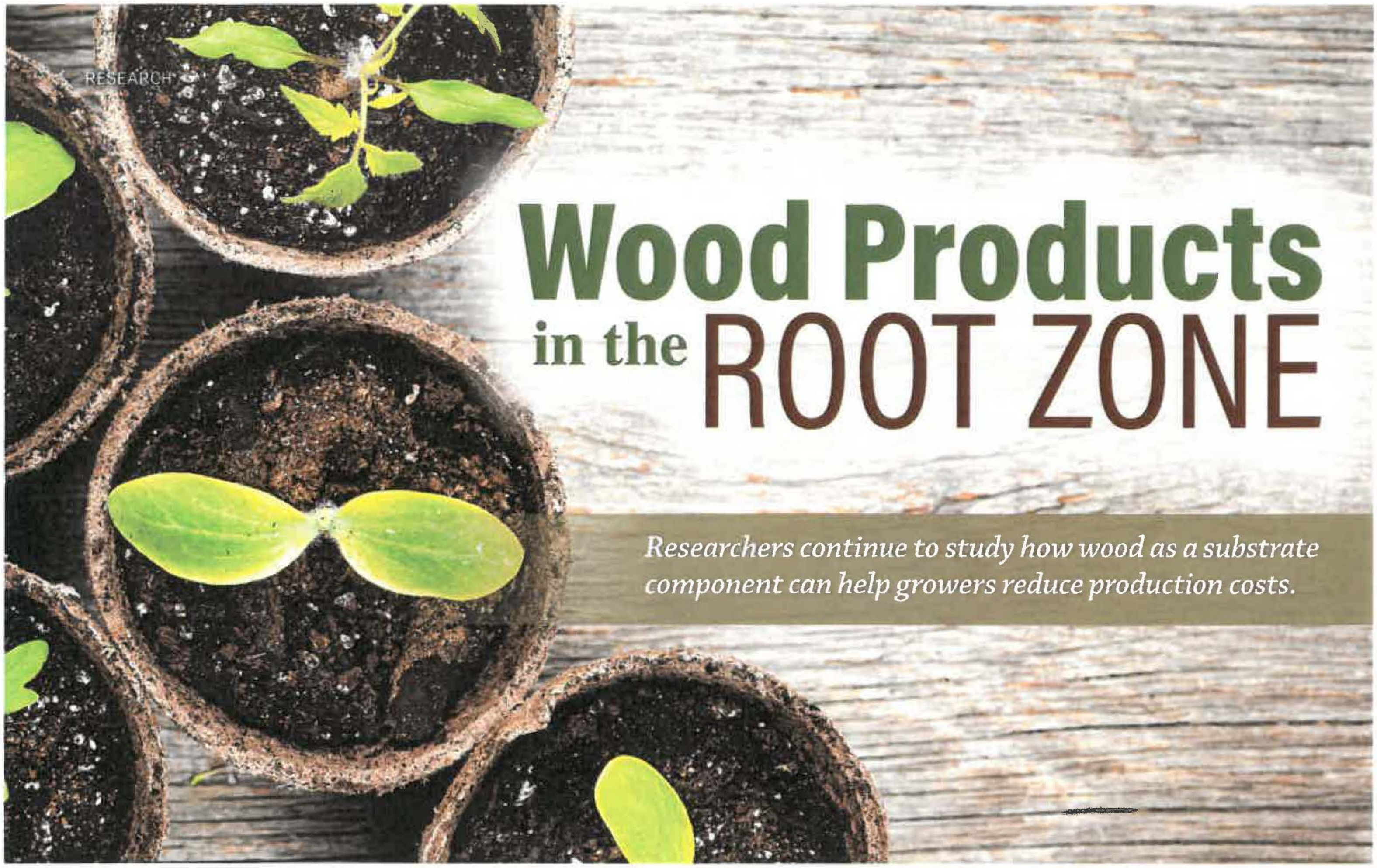

Wood Products in the ROOT ZONE

Researchers continue to study how wood as a substrate component can help growers reduce production costs.

BY BRUCE BUGBEE AND ROYAL HEINS

More than 30 years ago we started discussing nutrition and substrates for containerized production. Science is a ponderous enterprise. We are still optimizing. Our current challenge is to determine the modifications necessary to use high fractions of wood in peat-based substrates.

Wood products can be 30 to 50 percent of the cost of peat, but the addition of wood affects both the physical characteristics (water holding capacity and aeration) and the chemical characteristics (pH, nutrient holding capacity and microbial stability) of substrates. Our studies have included treatments with up to 75 percent wood by volume because some useful modifications become more aparent in high wood treatments, and because we think wood substrates can ultimately be used at high percentages of the substrate.

POTENTIAL VS. EFFECTIVE WATER HOLDING CAPACITY

Water holding capacity is the difference between the maximum volume of water a container can hold after watering and the volume when the plant wilts (Figure 1). Like the gas gauge in a car, each time the pot is fully watered, it fills the tank.

The potential water holding capacity of an 80/20 peat/perlite substrate is about 60 percent of the substrate volume. The exact potential depends on substrate settling (density) and pot height. Our data indicate substrates with either sawdust or shredded wood hold slightly less water; the potential capacity declines from 60 to 50 percent as the percentage wood increases to 75 percent (Figure 2).

This potential capacity, however, can only be reached if the maximum water volume is achieved after watering.

Substrates become difficult to fully rehydrate when they get close to the minimum water holding capacity. Because of this, the effective water holding capacity can be less than half of the potential. Our studies indicate that adding a wetting agent can help to improve the effective water holding capacity — especially in substrates with higher fractions of wood.

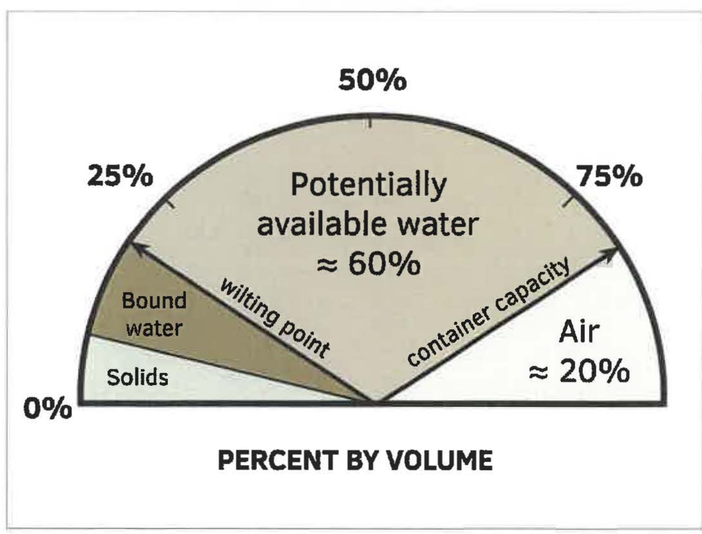

Figure 1. Tracking the water holding capacity of a container is similar to a gas gauge in a car.

When applied at the maximum label rate, wetting agents (WA) can increase the effective capacity to 90 percent of the potential capacity after a single watering. Wetting agents cost from about $1 (liquid) to $3 (granular) per cubic yard, but this is a small cost if it allows for easy and full rewetting when using a higher fraction of wood in the media.

WATER MOVEMENT

The ability of water to move vertically and horizontally in a container is important to maintain uniform water in the root-zone. The wicking of water to the surface of a container is often reduced with higher fractions of wood. This makes it appear that the plants need to be watered when only the surface is dry (Figure 3). The reduced movement of water is caused by reduced ability of water to move from wet to dry areas (called reduced hydraulic conductivity). If water moves slowly to the surface it also moves slowly from side to side. Hydraulic conductivity can be improved by adding a wetting agent (WA). Not only do substrates with a WA absorb water more quickly and evenly at the first watering, they rewet more quickly and uniformly in subsequent waterings. Our studies suggest that the addition of a WA is particularly beneficial in substrates with more than 50 percent wood, regardless of the wood's texture.

EFFECT ON PLANT GROWTH RATE

Fresh sawdust contains numerous compounds that can inhibit plant growth. The Crop Physiology Laboratory at Utah State University has conducted eight comprehensive growth studies with wood percentages up to 75 percent. So far we have studied: petunias, pansies and dianthus (from plugs); and cucumbers, sunflowers and tomatoes (from seed). Somewhat surprisingly, the effect of wood was similar for each of these diverse species.

All studies included liquid feed with a 21-5-20 fertilizer; which was applied at both our standard (120-ppm nitrogen) and at an elevated (240-ppm nitrogen) fertilizer rate. The pH of all containers was maintained at 6.2 ±0.4 with custom additions of dolomitic lime to each mixture. The buffering capacity of the wood products was insignificant compared to peat, so the lime addition rate depended on the percentage and buffering capacity of the peat. These studies have not yet included a wetting agent, but plants were frequently watered to minimize water stress so we could examine only the chemical effects of the wood.

We expected that more aged sawdust would result in better growth than less aged sawdust, so we tested both one- and three-month-old sawdust. The red line in the graphs is sawdust stored moist for about one month after sawmill cutting. The blue line represents sawdust stored moist for about three months. No fertilizer was added during storage.

The shredded wood (HydraFiber in these studies) was not aged, but the high temperature in the shredding process can cause the equivalent of rapid aging. Plants were grown

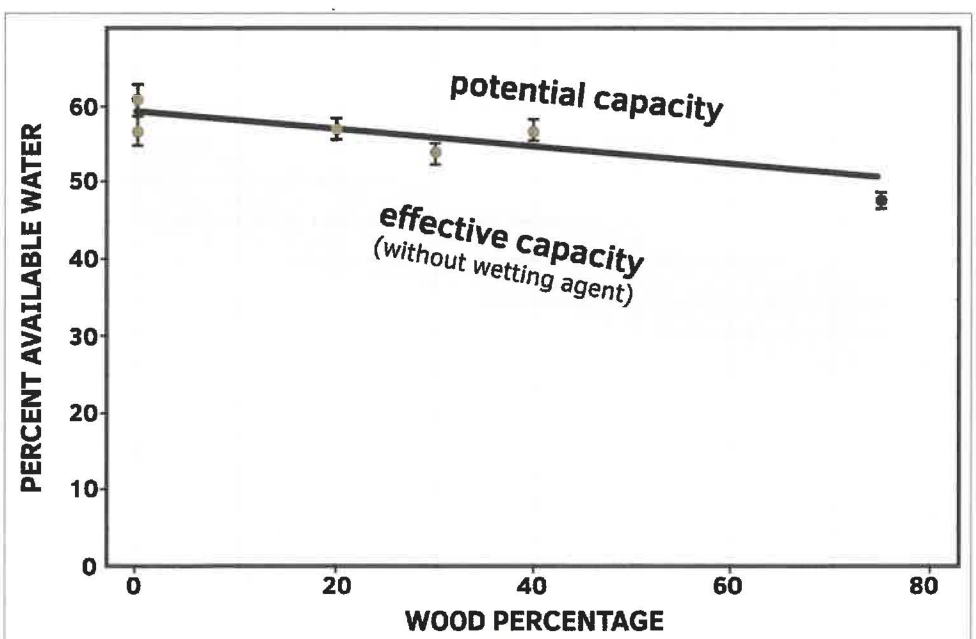

Figure 2. The potential water holding capacity decreases as the percentage of wood increases.

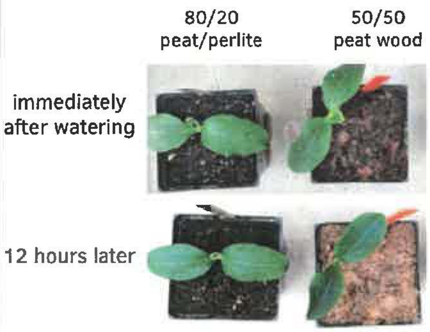

Figure 3. Wicking of water makes it appear that a plant needs to be watered when only the surface is dry.

Figure 4. Cucumbers and tomatoes are just two of the crops being evaluated at Utah State University.

for about 25 days from seeding or transplanting. Figure 4 shows a representative study with cucumbers and tomatoes.

The effect of wood percentage on whole-plant fresh-mass and typical plant appearance are shown in Figures 5 and 6. The error bars are the 95 percent confidence interval across all species. In each study, there were two types of controls for a reference: 50/50 peat/vermiculite and 80/20 peat/perlite. Aging the wood improved growth, but the benefit was less than we expected.

CONCLUSIONS

1. The 50/50 peat/vermiculite (PV) and the 80/20 peat/perlite (PP) were nearly identical in every study. Vermiculite has excellent nutrient holding capacity, provides silicon to reduce disease, buffers pH and is a natural wetting agent. These characteristics did not increase crop growth in these studies, so the combination of the PV and PP treatments provided an excellent, double reference for comparison of the wood treatments.
2. The elevated fertilizer level only slightly increased (less than 10 percent) the growth of the crops in the peat/vermiculite and the peat/perlite substrates. Fertilizer in excess of plant needs (especially nitrogen) can increase fresh mass of some plants, but in this study the plants were leached with about 15 percent of input solution volume at each watering. This would have replenished the nutrients in the root zone and provided ample nutrition at 120-ppm nitrogen. The results also show that over a wide range of plant species a 120-ppm nitrogen fertilizer solution is ample to meet plant nutritional requirements in substrates without wood.
3. Elevated fertilizer did increase plant growth in the treatments with wood, and the benefit increased with increasing fraction of wood (Figure 7). Based on tissue analysis, elevated fertilizer slightly increased N and phosphorus concentrations in leaf tissue, but the concentrations at 120-ppm nitrogen were adequate to support rapid growth. We do not yet fully understand the physiological basis for increased growth with increased nutrients in high wood percentage media.

   There may be indirect benefits of elevated fertilizer. The electrical conductivity (EC) of the leachate from containers with the same input solution decreased with increasing percentage of wood. This suggests microorganisms are growing on compounds coming from the wood and consuming nutrients. This microbial growth may be beneficial if they break down toxic compounds coming from the wood.
4. The treatments indicated by the one- and three-month labels are from aged sawdust, both lodgepole from Utah and loblolly pine from

North Carolina. The results, so far, have not indicated a significant difference between the two species of pine.

5. At 25 percent wood, growth in both the 3-month-old sawdust and shredded wood were nearly identical to the control treatments, and with added fertilizer there was only a 15 percent reduction in growth with 50 percent wood. The results indicate that increased fertilizer is beneficial with higher fractions of wood.
6. When effective water capacity is significantly less than potential water capacity, a container holds less water than possible. Less water in the pot means the plant dries out to wilt sooner and can result in the requirement for more frequent irrigations at retail and the development of water stress symptoms of chlorosis or necrosis if irrigations are delayed. Adding a solution with wetting agent prior to shipping should be beneficial in the retail market, especially for plants grown in high wood percentage substrates.
7. Plants in the high fraction wood treatments did not necessarily show unusual visual symptoms other than reduced leaf expansion and sometimes reduced height. Reduced height may be good, but reduced leaf expansion reduces photosynthesis and growth. Inhibitory compounds coming from the wood act more like a growth regulator than an herbicide. *It is important to note that without plants growing in a media without wood for a side-by-side comparison, the reduced growth might not be apparent. Even with a side-by-side comparison, differences of 15 percent fresh mass can be difficult to visually detect. Finally, even with reductions in growth, the plants may still be more than adequate for sale as floriculture crops often require the use of plant growth regulators to reduce size and height.*

A UNIQUELY SENSITIVE CROP

We have not yet studied poinsettias, but the experience of several growers suggests they are uniquely sensitive to sawdust. Interestingly, poinsettias appear far more sensitive to sawdust than to shredded wood. Some growers report using up to 50 percent shredded wood (HydraFiber) without problems. High temperatures during the shredding process might be removing inhibitory compounds.

Figure 8 shows poinsettias with 30 percentage fresh sawdust compared to a peat/perlite control. The plants with sawdust later recovered following leaching and high fertilizer applications and were saleable, but the reasons for the acute sensitivity of poinsettias

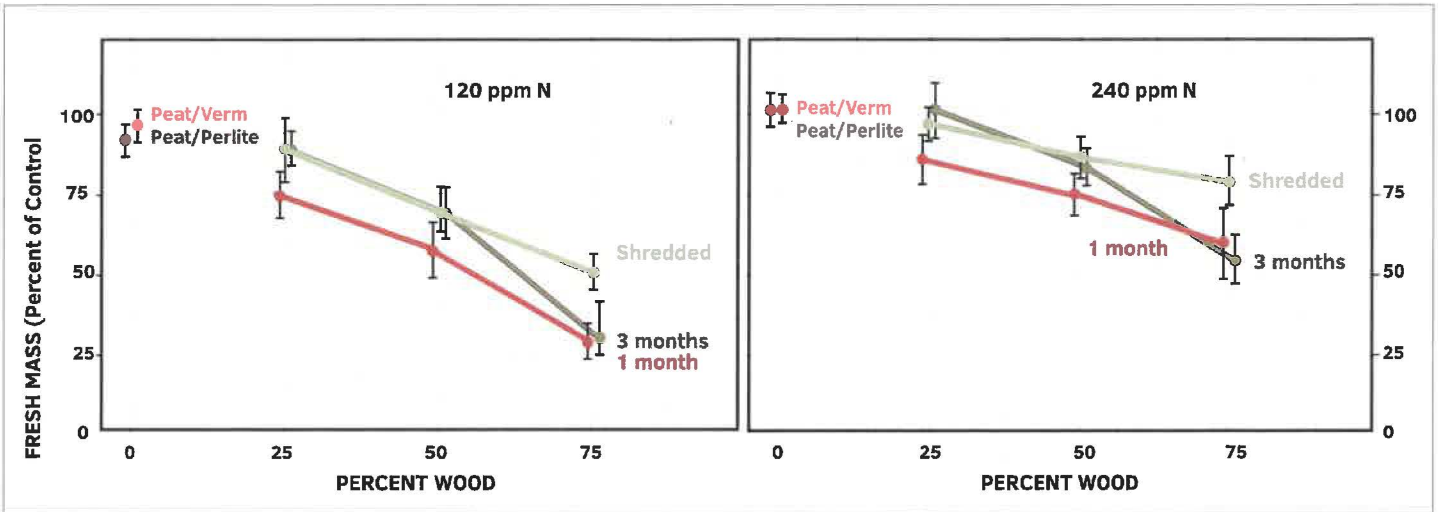

Figure 5. Shown here is the effect of wood percentage on a whole-plant-fresh-mass. Aging the wood did improve growth slightly.

are not yet known. The moral of the story: be careful when extrapolating from one plant species to another.

MICROBIAL STABILITY OF WOOD

A widely used indicator of the stability of compost is the biological oxygen demand (BOD). If the substrate is releasing low-molecular-weight organic compounds (e.g., phenols, terpenoids, creosote), microorganisms will grow and the substrate will consume oxygen. Our measurements indicate that fresh, moist sawdust has a BOD three times higher than four-month-old moist sawdust. Sawdust without sufficient moisture has a minimal BOD and ages slowly.

Four-month-old sawdust and all seven types of shredded wood we have tested have twice the BOD of peat. This means that they have twice the microbial activity. The high microbial activity does not directly reduce plant growth, but it indicates that the low-molecular-weight compounds are not fully degraded and may be inhibiting growth.

Adding fertilizer (mostly nitrogen and phosphorus) more than doubles the BOD of wood products, and they can be stabilized more rapidly

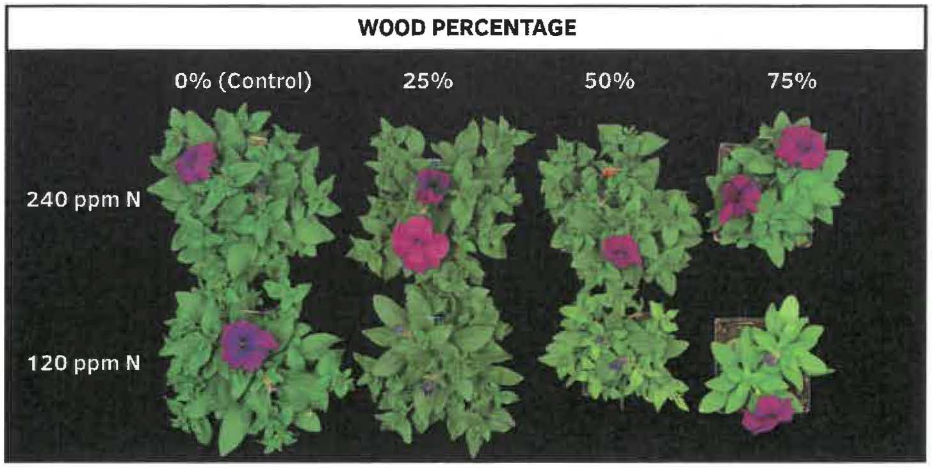

Figure 6. Plant size decreased as the wood percentage increased.

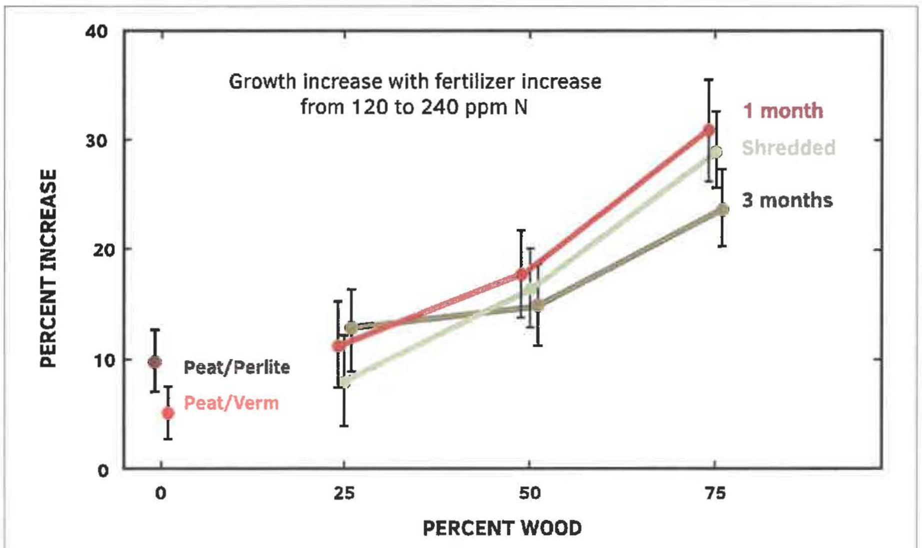

Figure 7. Elevated fertilizer increased the plant growth in treatments with wood.

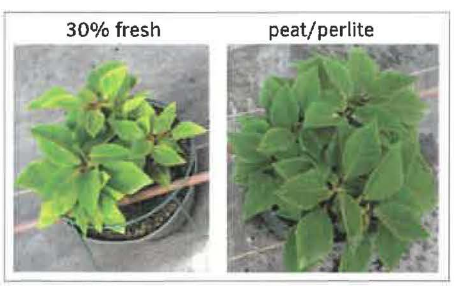

Figure 8. Preliminary research has shown that poinsettias appear to be more sensitive to sawdust compared to shredded wood.

than moist wood without added nutrients. The nutrients are initially consumed by the microbes but become slowly available to the plant after the substrate is stable and the microbial cells die and release the nutrients.

The time needed to stabilize wood products so they are similar to peat is not yet known, but if wood can be used at 75 percent of the volume without reducing growth it might justify the cost of aging.

We are continuing to study wood as a substrate component to help growers reduce production costs. Many growers have been successfully incorporating wood into their mixes for years. There have been challenges in adjusting pH and avoiding fresh wood, but there is broad interest in using higher percentages of wood as the problems get resolved.

Acknowledgements: *The authors appreciate the conscientious technical assistance of Boston Swan, Jakob Johnson, Paul Kusuma, Will Wheeler, Shuyang Zhen and Alec Hay.*

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